true with the subject of behavioural change in relation to house occupancy rates raised above. The recent philosophy of low-cost housing in Kenya, whilst recognising the ideal of single family occupation, has also acknowledged financial realities. Housing cannot be afforded by low income groups in terms of infrastructure and loan repayments, without recourse to sub-letting. This principle is fully accepted here. However, the question is how much sub-letting is reasonable given that over-occupation brings health disbenefits. If a plot allottee is allowed to build and rent, say, six rooms there could easily be in excess of eighteen people using one toilet. At such a rate of utilisation two things can be expected to happen. First, responsibility for cleaning and maintenance becomes blurred with the result that it is not done. Second, the problem of sheer access becomes difficult particularly at peak periods of defaecation in the mornings. Allowing that average occupancy time is only say 2-3 mins/person, this could entail unacceptable waits of 30-60 minutes! Children with diarrhoea can be expected to seek other solutions.

We recommend then that there has to be a balance between sub-letting as a means of affordability and house occupancy rates. Allottees should not be allowed to construct more rooms than necessary to ensure loan repayments. The object of low-cost housing is not to create a generation of idle landlords.

3.2.4 As far as more direct physical housing design and services aspects are concerned, we conclude from Section 3.1 (and the evidence on which it is based) that sanitation choice is by far the most important assuming that its provision is accompanied by appropriate education on its use resulting in appropriate behaviour and adequate management on the part of authorities. We conclude from discussions in Appendices I and II that:-

- water to the household is infinitely preferable to water from central collection points. Where the latter is the only feasible system, it should be regarded as a step towards the former and planned for with that in mind;

- the most important use of that water (apart from obvious minimum bodily consumption) is in regular hand washing after toilet use or contact and before all food contact. Provision should therefore be such as to make this very convenient. It follows that the quantity of water available is more important than the quality and, therefore, expensive efforts to achieve unnecessary levels of purity above basic pathogen security are not a high priority;

- designers must give more attention to the inter-relationships between water provision and excreta disposal. In areas where water is scarce, it is more important that what is available is used for personal hygiene than for flushing toilets and, therfore, conventional water-borne sewage is inappropriate in such areas - other safe excreta disposal technologies are available;

- sanitation choice must be realistic in terms of affordability, health performance, water availability, self-help construction potential, cultural factors affecting use and especially anal cleansing practice, site and soil constraints etc. A range of choice is available as discussed in Appendix II and methods to assist appropriate choice will be detailed in the Manual.

- toilets on the individual plot are infinitely preferable to communal facilities. The latter as disliked everywhere and rapidly decline into an insanitary state forming a focus for disease transmission. Where affordability levels are low, a cheaper technology on the house plot should be preferred to a communal water-borne system.

3.2.5 From our discussions, we conclude that most other physical aspects of the house do not directly very much concern health. Obviously, there are limits to the validity of this statement - 'houses' without roofs or 'houses' that act as drainage channels for ground or surface water are obvious extreme exceptions. We must assume, however, that no housing authority will be content with such glaring deficiencies.

More to the point, from Figure 3.1 and the accompanying discussions, it can be seen that both the location of housing and planning and control of the site are more important to health than design aspects of the dwelling. We conclude that aspects of space allowance, construction materials, ventilation etc. are of minor interest to health. Certainly these aspects must not - because of a legal demand for expensive standards - prohibit families from gaining the health benefits that other housing factors are known to bring. They have more to do with comfort, consumer desires and social expectation etc. than with specific or even non-specific disease incidence. If there is money available, then these aspects may be provided - they can be given the benefit of the doubt as it were. But if there is insufficient money, they come a long way down a priority shopping list in favour of the other aspects discussed in 3.2.1-3.2.4.

We have noted, however, one aspect of house design that may bear an important relationship to health - namely, cooking and heating arrangements. We conclude that more attention must be given to simple, cheap designs for safer cooking space in or outside of <u>each room</u> in a low-cost house and not just in a defined kitchen space which evidence proves will be used by only one family living on the plot.

3.2.6 Management by authorities is seen to be important - and this excludes management by health care authorities discussed under 3.2.1. It is particularly important for maintaining the operation of sanitation systems - all sanitation technologies (except pit latrines in ideal conditions) require some degree of maintenance by authorities.

Solid waste disposal is also important although the degree of importance may vary from place to place.

It has to be realised, of course, that urban public authorities are already under severe pressure of high demand and limited resources. Again, however, the principle should be borne in mind that low-income housing areas should be given high priority.

In addition, as we have suggested elsewhere these authorities must seek newer, less expensive technologies (ways of doing things) to meet these growing needs. We have suggested that more community involvement may be appropriate in terms of 'barefoot' sanitary workers etc. (see Appendix II).

3.3 A new emphasis for standards

What we are recommending therefore is an important shift of emphasis in priorities as far as housing and health are concerned. We are arguing that with the exception of sanitation technology choice (and its detailed specification) concepts of housing standards must move away from their present exclusive focus on physical, design aspects of the dwelling because these are not the really important health-related things.

Health interests are better served by satisfying guidelines (standards if that is what is desired) on:-

- preventive and curative health services;

- improving occupants socio-economic status by legalising their existance, improving their incomes and education etc;

- housing-related behavioural change induced by education (e.g. sanitation use) and by design/financing arrangements (e.g. occupancy rates);

- sanitation choice;

- housing location;

- site design and control;

- management by authorities;

than they are by construction and design standards for the actual dwelling.

It will be noted that, many of these important aspects are outside the control of the individual household. Criteria or standards for housing must therefore be focussed more on the performance of authorities than on the performance of the house.

This will no doubt be an unpopular recommendation as far as authorities are concerned. But if health is the objective, we see no option. Why should financially disadvantaged social groups be held responsible for meeting certain standards of things that are (in theory) under their control when in fact these things are by and large peripheral to the public health?

If public authorities cannot meet their responsibilities (which are health effective) why should the urban poor be expected to compensate (in ways which are largely ineffective).

The public health is better served by enabling these people to gain a foothold in society from which they may increase their socio-economic status and eventually their health. We have argued that the only really important constraints on communities in connection with housing change are concerned with sanitation choice and house occupancy rates. In fact, it is doubtful if even these things should be allowed to stand in the way of families in gaining a legal dwelling. However, this would be largely an academic discussion since, providing appropriate sanitation choice is made, neither of these two factors need inhibit the acquisition of a house. Part of the definition of appropriate sanitation is that it is affordable and many cheap, safe technologies are available. Similarly, controls on occupancy rates are achievable whilst maintaining the principle of sub-letting within limits sufficient to guarantee housing loan repayment levels.

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Section 4

DIRECTIONS FOR CHANGE

4. DIRECTIONS FOR CHANGE

In the final version of this Discussion Paper, this Section will present our specific recommendations for change. We feel that it would be unproductive to present those prematurely without discussion of the main arguments made in this first draft of the Paper.

Nevertheless it is perhaps useful at this stage to outline briefly some of the directions in which our arguments take us and what broad implications these may have for proposed change.

We believe these include the following:-

- the broad philosophy of legislative control should be such as to enable many more people to gain the health benefits of housing;

- it should not be unduly restrictive and impose unnecessary burdens on those most in need of those benefits and who are least able to respond to those restrictions;

- legislation should recognise that most of the strongly health-related aspects of housing are largely outside the control of the individual poor urban household and rest instead with various authorities. If those authorities are unable to respond appropriately, large concessions should be made to the urban poor to enable them to find their own solutions without the imposition of restrictions referred to above;

- the approach to legislation should assume that given the opportunity the poor urban family will work to improve its economic, social and environmental circumstances. Legislation should aim to maximise that opportunity;

More specifically :-

- it is not possible rigorously to or even usefully to define many performance standards for housing or its associated services as far as health is concerned;

- instead, legislation should aim to state the broad objectives that it aims to achieve and should illustrate these on a 'deemed to satisfy' principle;

- such legislation should be supported by further illustration of objectives in terms of guidelines explaining the intention of the law, the technologies that are known to meet that intention and as comprehensive as possible a description of circumstances and conditions for which each technology is suitable or unsuitable;

- absolute restrictions should be kept to a minimum and should be limited to subjects about which a substantial amount of knowledge exists;

- a mechanism should be established with which decisions can be taken about new entries in the 'deemed to satisfy' technologies;

- in the course of planning and design of public housing developments, responsible agencies should be obligated to demonstrate that they have considered cheaper 'deemed to satisfy' technologies and solutions than those incorporated in the final design. They should be obligated to demonstrate why these technologies are unsuitable in the circumstances. A precedent exists for this approach to legislation in the form of compulsory Environmental Impact Statements that perpetrators of major physical change are obliged to prepare in the USA. These demonstrations need not be elaborate, time consuming documents.

- whenever and wherever municipal or local authorities refuse planning permission for a public, low-cost housing scheme, they should similarly be obliged to demonstrate precisely why the proposals do not conform with the intention of the law and/or with 'deemed to satisfy' technologies;

- public low-cost housing development agencies are to demonstrate the suitability of site selection from the points of view of:

    - absence of vector borne disease risk and/or to show actions taken to reduce these risks;

    - access to known employment centres and/or to show actions taken to facilitate on-site informal sector employment opportunities;

    - access to health care services and/or actions taken to facilitate such services;

- where water is not to be provided to the household, the housing authorities to demonstrate:

    - that cheaper ways of doing so have been considered and rejected and reasons are to be shown;

    - the extent to which standards of other aspects of the scheme would have to be reduced to make household water affordable;

- responsibilities for nuisances to be clarified in the low-cost housing legislation and in plot allocation/lease agreements. Allottees will be made responsible for their occupants and real measures are to be available to enforce this responsibility;

- standards are to be worked out to balance maximum permitted occupancy rates with affordability (need for sub-renting) in new housing developments.

APPENDIX I

EPIDEMIOLOGY

1. Arthropod Transmitted Diseases

2. Airborne/Contact Diseases

3. Excreta-Related Diseases

4. Maternal & Child Health and Nutrition

5. Accidents

6. General Acute & Chronic Disorders

7. A Note on Health & Vital Statistics

1. ARTHROPOD TRANSMITTED DISEASES

This group of infections requires arthropod vectors (mosquitoes, flies, ticks etc.) for transmission to man. The infections may or may not have a secondary reservoir in species other than man. For example, malaria is a disease exclusively of man and certain mosquitoes whereas plague is transmitted by fleas but also infects rodents.

The infections themselves include parasites, viruses, bacteria and bacteria-like organisms. Those discussed in this Section as being of relevance in Kenya are:-

Malaria
Trypanosomiasis
Leishmaniasis
Filariasis
Onchocerciasis
Viral diseases (arbroviruses)
Plague
Relapsing fevers
Rickettsioses

Control of the natural and domestic environment is thus an important aspect of the control of these diseases. An effective point of intervention in the cycle of transmission is not so much to attack the agent of the disease itself (i.e. the parasite, bacteria etc.)* but to achieve a reduction in man-vector contacts by reducing the vector population in the vicinity of human activity.

Housing development is thus highly relevant to this group of infections since it provides opportunities to create conditions unfavourable to the vectors of disease important in that particular area. The degree to which this is achievable depends largely on the habits and adaptability of the vector concerned and on the assessed cost-benefits of the situation.

*This is not to say, of course, that attacking the agent of the disease is not effective - it often is very effective and is precisely what is attempted with chemotherapy treatment of infected individuals.

Conversely, new housing settlements that are developed (or that have developed spontaneously) without regard to these diseases, risk creating favourable conditions and an increase in local vector densities.

NAIROBI		Altitude thought to ensure that little or no transmission occurs but city is sited on edge of a 3-6 months transmission zone so occasional outbreaks not impossible.
THIKA	*	As above but higher risk of localised outbreaks.
NAKURU	*?	Only very rarely along stream courses.
MACHAKOS	**	Mesoendemic area - spleen rate 10-49% (Roberts 1974). There have been epidemics (e.g. 1972); transmission period 3-6 months. Should be considered as a real risk here.
ISIOLO	**	Probably as above, lower spleen rate on average but with higher localised risk depending on altitude.
MERU	*	Not much of a risk in the township.
MOMBASA	*** endemic	High prevalence - spleen rate 75% (Roberts 1974) - more than 6 months transmission period. 'Clinical' rate from Weekly Notifications 1962-72 is 60/100,000.
LAMU	*** endemic	As above.
KAKAMEGA	**	Risk of epidemics. Probably localised.
WEBUYE	**	As above.
KISUMU	*** endemic	Second highest prevalence after coastal area - spleen rate 50-74% (Roberts 1974).
KAJIADO		Very small risk and even then only near water.

* denotes risk of occasional epidemic (i.e. seasonal transmission)

** more serious risk epidemic

*** endemic situation

The Disease and its Transmission.

Malaria is a parasitic disease transmitted by infective mosquitoes.

The most important form of the disease in Kenya is Plasmodium falciparum. The most important vectors are Anopheles gambiae and Anopheles funestus.

A. gambiae tends to breed in temporarily sunlit clear pools often those resulting from human activity. Where such pools or other collections of water maintain high temperatures breeding can occur in as little as 5-6 days but usually takes longer. Breeding and therefore larger vector populations, therefore tends to occur at the beginning and during rain seasons. A. gambiae is a night-feeding mosquito.

A. funestus prefers clear shallow water with vegetation especially swamp land, quiet lakes or ponds fringed with vegetation as well as some clear streams. A. funestus is primarily a day-feeding vector.

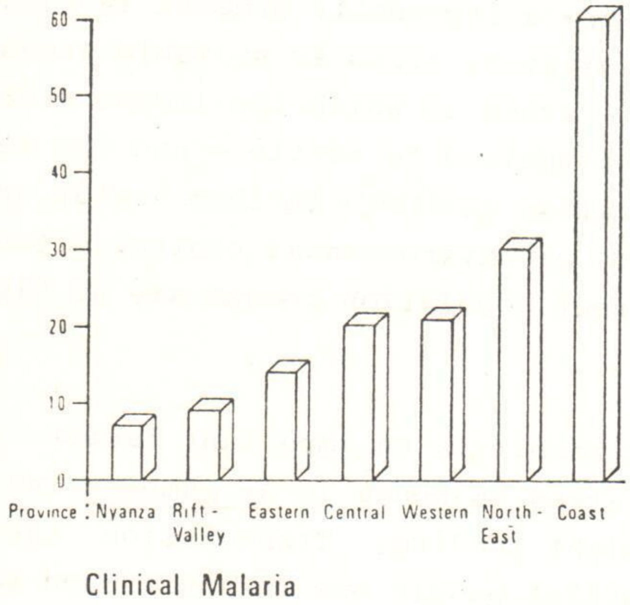
Thus apart from the case where housing development is situated adjacent to swamp land or comparable natural habitats of A. funestus, the main malaria vector of concern to urban populations is A. gambiae.

Distribution.

Large scale malariological surveys are unavailable so that data is very approximate and mostly confined to general regional variation. Furthermore, reportings of the disease in Weekly (or Monthly) Notifications of Infectious Diseases from the district medical offices are more often than not based only on clinical diagnosis unsupported by parasitological confirmation.

Nevertheless, wide regional variation is evident as illustrated in Figure I,1.

Figure I,1. Rate/100,000 population (for median year 1969) for years 1962-1972 from Weekly Notifications of Infectious Diseases, MOH.



Source: Diesfeld, 1978.

More specifically for present purposes, age-specific spleen rates* reported by Roberts (1974) provide the following:-

Location	% Positive	Comment
Coast	75%	Known endemic area including Mombasa and Lamu.
N.Nyanza/Bungoma	50-74%	Probably includes Kakamega, Webuye and parts of Kisumu.
Machakos/Thika	10-49%	
Meru/Isiolo	10%	Very dependent on altitude and probably higher than this in parts of Isiolo.
Masailand	Variable	Probably includes Kajiado

* The rate at which an enlarged spleen is detected in a survey of children from 2-9 years. Note, however, that an enlarged spleen can be caused by disease other than malaria.

At a more micro level, malaria is not a disease that can be directly associated especially with the target populations of this Project - all social groups are at risk. However, micro ecologies are all important determinants of malaria transmission and populations frequently present in such areas are at higher risk. Habitation close to suitable areas of natural water or swamp - areas in which low-income groups are often economically compelled to settle - and the tendency for low-income housing areas to create further vector breeding sites through their lack of environmental control often do ensure that Project target population groups are at higher risk.

The quality of housing itself is an important factor. The major vector in urban areas in Kenya is A. gambiae and this particular vector is night feeding. Transmission, therefore, occurs predominantly whilst people are in and around their houses during the evening and sleeping at night. Low quality structures permit easier access for mosquitoes and additional hiding places for them during daylight hours. Similarly, over-crowded and difficult to-ventilate structures encourage doors and windows to be left open at night and, particularly in the coastal and Lake Victoria areas, encourage people to sleep outside thus exposing themselves to maximum risk.

Furthermore, where a reservoir of plasmodia is present in a population (for example a population migrating from a poorer rural area where malaria is endemic), an increase in the vector population following excessive rainfall can be sufficient to create epidemic conditions.

Intervention.

Decisions relating to intervention in malaria transmission are notoriously difficult. In areas where the disease is endemic a stable situation arises in which, through constant infection from childhood, populations gain a degree of immunity. Of course this immunity is maintained at the cost of high infant morbidity and mortality before immunity is gained. The problem with intervention in endemic areas is that unless the intervention programme is very effective and maintained over some years, it can replace continual infection with occassional infection (i.e. at periods of seasonally high rainfall) between which much of the populations immunity is lost and adults (as well as infants) will experience increased morbidity and mortality rates. Unless, therefore, a serious public health commitment to a sustained eradication programme is planned, piecemeal tinkering with malaria control can introduce more problems than it solves.

On the other hand, in areas that are at risk of occassional epidemics, the undesirable situation described above already exists and everything possible should be done to reduce the size of the vector population and the risks of transmission.

In particular housing should not be located in areas where the surrounding natural environment is known to be conducive to mosquito breeding and where large mosquito populations exist i.e. in undrained land with shaded vegetation.

Housing as an intervention itself (in sites-and-services or upgrading schemes) should emphasize drainage aspects of mosquito control rather than protection through window netting etc. The latter reduces ventilation considerably and, particularly in the coastal area, may be itself an added incentive for people to sleep outside thus putting themselves at maximum risk of infection from A. gambiae.

Adequate surface drainage is important in high risk areas but it should be noted that the mechanisms of drainage can themselves constitute mosquito breeding sites particularly for A. gambiae. Drainage channels should aim to achieve fast water flows, rapid drying out performance and if this is not possible, frequent changes of water level.

also the use of insecticides. For example, Abate added to water storage containers and to ground pools is particularly effective against *A. gambiae* and *A. funestus*. However, this is expensive over the periods necessary to break transmission cycles and, in any case, should never be carried out without the supervision of the national authorities (the MOH Division of Vector Borne Diseases) for risk of introducing insecticide resistance in the vector population.

NAIROBI	*	No very recent outbreaks but should be considered high risk area.
THIKA		
NAKURU	*	There have been various outbreaks in Rift Valley towns.
MACHAKOS		
ISIOLO		
MERU		
MOMBASA		
LAMU		
KAKAMEGA		
WEBUYE		
KISUMU		
KAJIADO	*	Centre of outbreak in 1978 moving through Masailand to Nairobi.

* higher risk than elsewhere

The Disease and its Transmission.

The agent for the disease is *Yersinia pestis*.

Transmission occurs by the vector *Xenopsylla cheopis* (flea) and the disease has a reservoir in rodents.

Although rare in humans in Kenya, a natural reservoir exists in the large rodent population and large epizootics can occur but be unnoticed until man is involved. Indeed the geography and ecology of the country appear to be well suited to rodents and condusive to the flourishing of large populations in which such enzootic and epizootic states of plague almost certainly exist.

Exceptional climatic change (flood and drought) can cause rapid encroachment of the rodent populations on human settlements and plague should, therefore, always be considered as a constant threat.

Distribution.

The importance of the latent threat of plague was emphasized as recently as 1978 when an outbreak originating in Kajiado area spread to the outskirts of Nairobi - declining again for no obviously apparent reason. This outbreak was certainly a result of the dramatic increase in the wild and domestic rodent populations and the effects on population distribution following the unusually heavy rains in recent years.

The scanty data on the distribution of plague in rodent populations does not allow particular urban sites to be ranked in terms of risk. In 1968 a survey of 20,000 rodents in different parts of the country discovered significantly high antibodies in 2.5-10% of the sera. (Davis *et al* 1968).

Past outbreaks have occured at Rongai (1953), Murang'a (1963) and in Masailand centred on Kajiado (1978). If any Project towns can be singled out as higher risk they are probably Nairobi, Nakuru and Kajiado.

Slum areas in any town obviously present much higher risks than other areas.

Intervention.

Strong efforts should be made to control rat-human contacts not only for plague but for a wide range of health risks associated with rodents.

Control measures are mainly:-

- effective and regular disposal of solid waste to deny rodents access to food in human settlements. Container stands should be designed to reduce spillage and to deny access to rodents. Community education is important but must be supported by municipal action on a reliable basis.

- house construction which prohibits the entry of rodents and the maintenance of plot cleanliness and the regular disposal of unwanted materials etc. that provide hiding and shelter for rodents.

- rodent control measures by the public health authorities in high risk areas.

NAIROBI		
THIKA		
NAKURU		
MACHAKOS		
ISIOLO		
MERU		
MOMBASA	*	Should be considered a high risk area for outbreaks particularly chikungunya/ o'nyong nyong complex and Bunyamwera.
LAMU	*	As above.
KAKAMEGA		
WEBUYE		
KISUMU	*	As above.
KAJIADO		

ARBROVIRUSES

Arbroviruses are viral diseases transmitted by infective arthropods including mosquitoes, ticks and sandflies. They are characterised by an acute febrile illness that is rarely life-threatening but which may be temporarily debilitating sometimes seriously.

Arbroviruses present a picture of extreme complexity. There are something like 350 arbroviruses amoungst which over 90 are known to be pathogenic to man.

The following are probably the most relevant to Kenya:-

<u>Group A</u>
Chikungunya
O'nyong-nyong
Sindbis
Semliki Forest

<u>Group B</u>
Zika
West Nile
Banzi
Wesselsbron
Dengue-1
(yellow fever is also in this group but is rare in Kenya - see text)

<u>Bunyamwera Group</u>
Bunyamwera
Beliefe

<u>Group C</u> ?
Rift Valley (mainly a cattle disease but may be also human)

From amoungst this list, however, the most important arbroviruses are:-

Chikungunya - the vector for this is <u>Aedes aegypti</u>

O'nyong-nyong - vector <u>Anopheles spp.</u> A massive outbreak of this occured in the early '60s.

Bunyamwera - vector <u>Aedes spp.</u>

Distribution.

A serological survey to detect antibodies to a range of arbroviruses was completed in 1966-68 in three selected districts - Malindi, Kitui and Siaya in Central Nyanza. It was found that 50% of people examined had antibodies against the chikungunya/o'nyong nyong complex (they are immunologically indistinguishable) in Siaya and Malindi whilst in Kitui they were virtually absent. In Siaya and Malindi antibodies were present even in the 0-4 age group indicating that the infection was still present at that time. (Geser <u>et al</u> 1970).

In 1973 a study of the lakeside area south of Kisumu detected antibodies to chikunyunya/o'nyong nyong in 60% of school children. (Bowen <u>et al</u> 1973).

In the 1966-68 survey, Bunyamwera antibodies were found in 26% of the Malindi sample but only 5-6% from Siaya or Kitui.

Dengue-1 antibodies were similarly distributed with 47% positive in Malindi but with no clinical evidence of dengue.

An examination of 147,000 mosquitoes from seven areas of the country succeeded in isolating arbroviruses including Semlimi Forest, Banzi, Bunyamwera and Beliefe. (Metselaar <u>et al</u> 1974).

An arbrovirus of importance elsewhere is yellow fever but this appears to be almost entirely absent from Kenya. Nevertheless, antibodies are found indeed the 1966-68 survey found yellow fever antibodies in more than 50% of the tests in Malindi. However, unequivocal identification of many arbrovirus antibodies is very difficult from serological tests alone since cross-reactions to other antibodies can occur. It was suggested that these Malindi findings were attributable to such cross reactions (or to yellow fever vaccinations!). The concencus view is that Kenya is effectively almost free of yellow fever.

In summary, the major risks from arbrovirus outbreaks in Kenya are from the chikungunya/o'nyong nyong complex and from Bunyamwera. It is probable that these virus are circulating at low levels and that outbreaks could occur from time to time. Major epidemics would, however, probably require a quite substantial ecological change such as climatic change favouring the vectors or the introduction of a larger reservoir of infection through population movement etc.

The vectors of major importance are therefore Aedes spp. especially Aedes aegypti and Anopheles spp.

Intervention.

For the most part these arbroviruses are not sufficiently serious to the individual to justify costly control measures. However, major epidemics do take a quite serious toll in terms of debilitating effects albeit temporarily.

Levels of endemicity are probably not sufficiently high to provide much in the way of natural immunity in either of the two main foci and, in any case, the need for constant population mobility would still expose many non-immune individuals to risk of infection.

Efforts should be made therefore to reduce the vector populations in these areas and, to do so, much that has been said about mosquito control in the sub-sections on malaria and filariasis applies also here.

Environmental control in the urban and peri-urban areas is potentially important. Aedes aegypti is known to flourish in domestic and semi-domestic habitats (as well as more natural conditions including forests) wherever breeding sites are available in water storage containers, discarded tins, pots, tyres, plastic containers etc.

Site drainage, surface drainage, solid waste disposal, covers for clean water storage containers etc. will all assist in the reduction of Aedes spp. and Anopheles spp. within access to the site population.

House protection with netting etc. is likely to be counter-productive as mentioned with malaria control measures.

ONCHOCERCIASIS

NAIROBI	
THIKA	
NAKURU	
MACHAKOS	
ISIOLO	General Comments:-
MERU	For all practical purposes this disease has been eradicated from its original foci in Western Kenya.
MOMBASA	It is a rural disease and of no relevance to urban housing.
LAMU	
KAKAMEGA	
WEBUYE	
KISUMU	
KAJIADO	

The Disease and its Transmission.

A parasitic infection transmitted by the *Simulium* fly.

Parasite form *Onchocerca volvulus*.

Vector in Kenya *Simulium neavei*.

Distribution.

Whilst there were earlier a number of foci of onchocerciasis in Western Kenya, the disease has been almost certainly completely eradicated. However, extensive infestation exists on the Ugandan side of Mt. Elgon and a small focus may remain on the Kenyan side at Malakisi.

In any case, onchocerciasis is of little or no interest for urban housing development. *Simulium spp.* require ecological conditions that severely constrain their distribution. For breeding purposes they are restricted to fast-flowing streams and rivers usually in mountainous terrain. *S. neavei* has the additional requirement for a certain freshwater crab - the larvae live in the shells of these crabs to obtain a rapid flow of water and oxygen.

The major risks of reintroducing onchocerciasis in the Western Region comes from man-made irrigation and hydro-electric schemes which, without adequate consideration may extend suitable breeding sites for *Simulium*.

NAIROBI		
THIKA		
NAKURU		
MACHAKOS		
ISIOLO		
MERU		Transmission confined to coastal areas in Kenya.
MOMBASA	*	Remains an important risk around Mombasa but probably little transmission on the island itself.
LAMU	**	Remains a serious problem here.
KAKAMEGA		
WEBUYE		
KISUMU		
KAJIADO		

The Disease and its Transmission.

A parasitic disease transmitted by infective mosquitoes.

The form of parasite of major importance in Kenya is Wuchereria bancrofti.

The vectors are:-

- in urban areas Culex fatigans
- in rural areas Anopheles gambiae and A. funestus

Culex fatigans is essentially a domestic mosquito breeding in pit latrines, waste water pools and any collections of water in discarded domestic rubbish - tins, tyres etc.

A. gambiae (also the vector of malaria here) is also known to accept water pools etc. resulting from human activity as suitable breeding places and occasionally breeds in clean water storage containers. It prefers temporarily sunlit, clear pools.

A. funestus (malaria vector) prefers more natural habitats of swampy ground.

The main vector of conern to urban housing development is therefore Culex fatigans but A. gambiae can also be important. Both these vectors are night-feeders and given that Wuchereria bancrofti produces peak microfilaria densities in human peripheral blood at night, both these vectors are likely to be relatively efficient in transmission.

In comparison, A. funestus is not likely to be as important.

Distribution.

Filariasis is confined to the coastal strip of Kenya although the vectors are present in many parts of the country.

Within the coastal strip itself, the true extent of the disease is difficult to assess. Microfilaraemic carriers can remain symptom free for years and, in general clinical attack rates are thought to be low. But early infections are frequently unrecognised in indigenous populations in endemic areas.

The only consistant measure is the occurence of microfilaria in peripheral blood sample surveys. Such a survey was undertaken recently (Wijers 1977, Wijers and Kinyanjui 1977, and Wijers and Kiilu 1977) of 5,000 males over 14 years old in Kwale and Kilifi Districts. A 'filariasis index' was computed based on microfilaria rate and clinical signs. Four main foci were identified having an index score of above 50%. These were:-

- the extreme south of the coast strip
- west of Mombasa
- just inland from Kilifi
- along the Sabaki river

Lower but significant rates were found at Lamu and just north of Mombasa.

Current opinion is that of the two relevant Project towns, Lamu presents the more serious problem.

Intervention.

Chemotherapy is available and reasonably effective but frequently results in adverse reactions. From a control point of view the treatment is effective in rapidly lowering the density of peripheral blood microfilaria and thus reducing transmission risks but the problem is that many patients fail to complete an adequate course of the drug because of its frequent side effects and because many are in any case symptom-free.

The use of residual insecticides can be reasonably effective but resistance has developed in many parts of the world. These and antilarval measures depend on a thorough understanding of the behaviour of the vector and the history of control attempts. (WHO 1962, 1967, 1971, 1973).

A recent study in a coastal village in Tanzania (Bushrod 1979) achieved a successful reduction in the vector population by a combination of antilarval and environmental control measures.

These included:-

- adding Dursban to pit-latrines (breeding sites for *Culex spp.*).

- adding Abate to domestic water storage containers or fitting these with wooden lids with plastic gauze (breeding sites for *Culex spp.* and occassionally *Anopheles spp.*).

- weekly checking of small water vessels and rubbish around the village and any water disposed of (breeding sites for *Culex spp.*).

- treatment of ground water pools within 1 km radius with Abate (breeding places for *Anopheles spp.* - especially *A. gambiae*).

- treatment of brackish water pools with paraffin (breeding sites for *A. merus* - but this is not important in Kenya).

Although control measures were very localised - none beyond a 1 km radius, a substantial reduction in the vector population was achieved and apparently little migration occured.

Similar studies elsewhere have shown that successful vector reduction can be achieved in urban areas by the systematic drainage or filling-in of pools supplemented by larviciding.

It should be noted, however, that such a programme would have to be sustained over several years (seven years was suggested by White 1971) in order to break the filariasis transmission cycle. The cost of insecticides would be prohibitive on a large scale and their sustained use would be likely to introduce resistance.

Alternative methods of relevance to urban housing development include mainly:-

- the upgrading of pit-latrines (where there exists no realistic time-table for their replacement with water-borne sanitation) to render them mosquito proof. This is discussed in some depth in the sanitation technology section of this report.

- the location of new housing away from natural habits of filariasis vectors i.e. water logged ground, swamps, pools, ponds and lakes etc.

- adequate site drainage (where the above is not possible) and the provision of an adequate surface water drainage system to prevent the collection of rain water and waste water pools.

- protection of clean water storage vessels.

- effective solid waste disposal and environmental management to prevent the use of discarded domestic objects as vector breeding sites.

A fuller discussion of environmental control measures is given under the sub-section on malaria and much of that is relevant here. In general, housing developments should aim at a degree of control through drainage and environmental measures (and through improving latrines in the case of Culex fatigans) rather than through protective design methods such as window and door netting which will reduce indoor ventilation and in the coastal climate will encourage outdoor sleeping thus putting people at maximum risk of infection from Culex fatigans and A. gambiae.

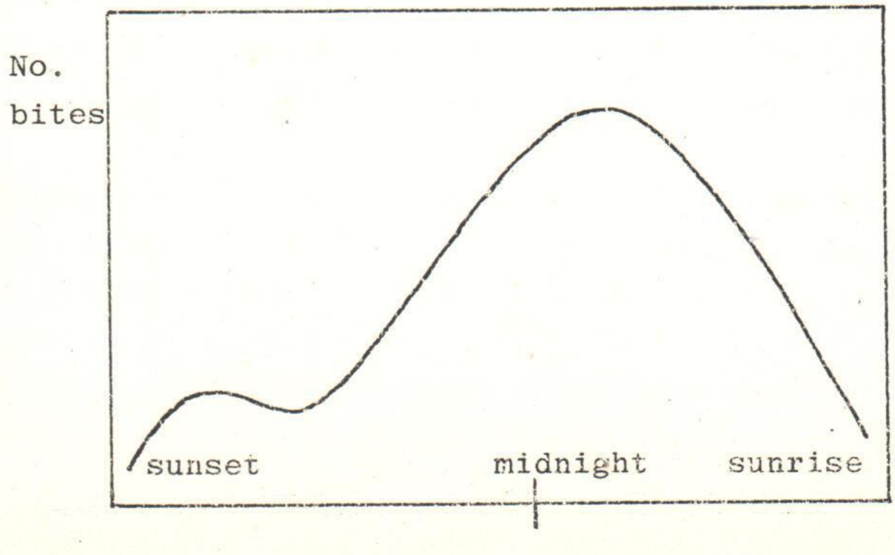
In areas where Culex fatigans is a major problem (e.g. Changamwe, Mombasa is now a major breeding ground) and where latrine upgrading is not yet feasible, other methods of breeding control may be applied.

Chemical larvacides like Dursban are very effective when added to wet pit latrines but - as noted above - will be very expensive over time.

Experiments of adding a layer of small polystyrene balls to traditional latrines have been undertaken with considerable success (personal communication McCrae, International Centre for Insect Physiology and Ecology, Mombasa). This layer of balls floats up and down with the water level thus barring mosquito access whilst not interferring with the functioning of the latrine.

In connection with the improvement of latrines, it should be borne in mind that even a few unimproved latrines in a community will be sufficient to maintain breeding. The breeding densities will simply become higher in these unimproved latrines when access is prevented elsewhere.

C. fatigans feeding pattern tends to follow the following:-



Peak risk, therefore, occurs when people are sleeping. The problems with house protection measures have been noted above but individual bed nets are known to be highly effective and do not reduce air flow so greatly.

It might be noted although house protection measures have been shown to be successful (assuming people remain sleeping indoors), and house counts have been reduced, this success may be simply due to the fact that mosquitoes have then gone where houses are unprotected.

NAIROBI		
THIKA		
NAKURU	*	
MACHAKOS	*	
ISIOLO	*	General Comments:-
MERU	*	Primarily a rural disease in Kenya, the only areas of major concern being the North East, the North and some areas to the north of the Rift Valley.
MOMBASA		Project towns reporting cases are indicated but these are almost certainly cases arising in surrounding rural areas.
LAMU		
KAKAMEGA		
WEBUYE		
KISUMU		
KAJIADO		

* towns reporting cases in recent years

The Disease and its Transmission.

A parasitic disease transmitted by infective sandflies.

The form relevant in Kenya is Leishmania donovani - kala azar. (Cutaneous leishmaniasis (L. tropica) is extremely rare in the country).

The vectors are sandlies of the phlebotomus group - principally P. martini.

Although in many parts of the world kala azar is transmitted by primarily house-dwelling vectors (e.g. P. argentipes in India), in Kenya P. martini is thought to be largely a rural disease limited to arid and semi-arid areas mainly below 2000 feet. In the past this vector has been strongly associated with eroded termite hills in which the sandflies inhabit the ventilation shafts. It was thought that the vectors only left these hills in warm, calm evenings especially at the beginning and end of rain seasons. However, there is now doubt as to whether this is in fact the case and there are certainly other habitats of the sandflies. There is some evidence that indoor feeding occurs and that anthills may only provide suitable resting places - Mutinga (1978).

Rodents and possibly dogs (Ngoka 1978) provide a reservoir.

Distribution.

Cases reported have been largely confined to the arid and semi-arid areas of the North and North East but including Machakos, Nakuru and Meru. However, these are almost certainly cases arising in rural areas. Population movements recently may be an important factor in the changing and increasing number of cases identified.

A recent study of an outbreak in Machakos District (Ngoka 1978) found an increase in parasitologically confirmed cases from below 10 in 1972 to 130 in 1977. Case follow-up traced these cases to rural homesteads. It was concluded that kala azar has remained at endemic levels in this area and that the recent outbreak results from the increased movement of people in search of food and water following the period of drought.

It is likely that the flight range of P. martini is small so that natural foci of transmission probably occur. Where these are close to rural water sources - river beds, dams etc. - the congregation of people can promote spread of the disease.

Intervention.

The most effective intervention is probably case finding and treatment. Since transmission probably occurs primarily outdoors, residual house spraying is unlikely to be effective.

Where housing developments are planned near to the known foci of transmission, existing termite hills should be destroyed and sprayed.

The control of rodents and dogs should be attempted through the management of solid waste dispcsal.

House protective measures such as window netting etc. will not be effective and will reduce ventilation performance.

NAIROBI		
THIKA		
NAKURU		
MACHAKOS		
ISIOLO		
MERU		
MOMBASA		
LAMU		
KAKAMEGA		
WEBUYE		
KISUMU	*	Kisumu is the only town under consideration anywhere near the remaining possible foci of transmission in Kenya. This is principally a rural disease and the dangers of transmission in urban areas is neglegible.
KAJIADO		

TRYPANOSOMIASIS

The disease and its Transmission.

Trypanosomiasis (sleeping sickness) is a parasitic disease transmitted by an infective *Glossina* (tsetse fly).

Forms relevant to Kenya are *Trypanosoma gambiense* and *Trypanosoma rhodesiense*.

The principal vectors are:-

- for *T. gambiense* - flies of the *Glossina palpalis* group.
- for *T. rhodesiense* - flies of the *Glossina mortisans* group.

but recently, *T. rhodesiense* has been found to be transmitted by *Glossina palpalis fuscipes*.

The natural habitat of the *G. palpalis* group has been in the forests of Uganda and western areas of Kenya especially along the streams and coastal areas of Lake Victoria - transmitting *T. gambiense*. Since the 1940's, however, migrant workers introduced *T. rhodesiense* into these areas which encountered *G. palpalis fuscipes* and a new transmission cycle occured.

Distribution.

Restricted to certain areas of South and Central Nyanza and Western Province in favourable local habitats. A serious outbreak of *T. rhodesiense* occured in parts of Central Nyanza and Western Province in 1964-65 but was rapidly brought under control.

Control measures have been very successful in the past and in recent years cases have been almost exclusively confined to resettlement areas and farmsteads especially around Lambwe Valley. Under favourable conditions, G. palpalis can spread from its natural habitat to farm vegetation.

Intervention.

Since trypanosomiasis is essentially a rural disease there is not a great deal that urban housing programmes can contribute positively or negatively to its reduction. The only serious concern might be the planned development of settlements in areas where the disease may still exist but these would be agricultural settlements and not the major concern of the present study.

NAIROBI	
THIKA	
NAKURU	
MACHAKOS	
ISIOLO	Not possible to identify relative risks.
MERU	Meru was a focus in the past.
MOMBASA *	
LAMU	
KAKAMEGA	
WEBUYE	
KISUMU	
KAJIADO	

* previous centre of infection

The Disease and its Transmission.

The agent of the disease is a spirochaete of the genus *Borrelia*.

Transmission occurs from ticks and body lice of various *Ornithodorus spp.*

The ticks favour a domestic habitat particularly where dirty surrounding provide cracks in mud and earth walls and floors.

Distribution.

Tick borne relapsing fever is now probably of neglegible significance in Kenya. Previously it was something of a problem around Meru and in cooler highland areas.

Intervention.

No specific interventions are called for in view of the low importance of the disease.

NAIROBI	
THIKA	
NAKURU	
MACHAKOS	
ISIOLO	
MERU	No specific distribution pattern known.
MOMBASA	
LAMU	
KAKAMEGA	
WEBUYE	
KISUMU	
KAJIADO	

The Disease and its Transmission.

Rickettsioses are infectious of bacteria-like organisms (Rickettsiae) transmitted by lice, fleas or ticks.

For the most part the infection has a reservoir in rodents and other animals but louse-borne typhus occurs only in man.

Neither louse-borne nor flea-borne typhus is reported in Kenya.

Tick-borne rickettsial disease also appears to be rare but is reported. But it should be remembered that diagnosis requires serological investigation and this is not at the disposal of many hospitals so that false reporting may occur.

In Kenya, tick-borne rickettsioses are:-

- tick-borne typhus (Rickettsia rickettsii but also possibly var. piperi and/or var. conori).

- murine spotted fever (R. mooseri).

- Q-fever (Coxiella burneti).

These are transmitted by a wide variety of ticks and have a reservoir in many rodents.

Q-fever is occassionally diagnosed and reported from Nairobi, Athi River and northern areas. But studies in 1976 (Vanek and Thimm) show that it is present in man (and cattle) everywhere that surveys were made - especially Eastern, Rift Valley and Coast Provinces. It is assumed that most adults are immune.

Unlike the other rickettsioses mentioned here, Q-fever whilst having a reservoir in ticks, wild and domestic animals, is commonly transmitted by the airborne dissemination of rickettsiae in dust. It can also be contracted by direct contact with infected animals or materials that they have contaminated - wool, straw etc.

Interventions.

No specific interventions are called for in view of the low importance of this infection. Increased skin and general household cleanliness will maintain low or neglegible incidence.

2. AIR-BORNE & CONTACT DISEASES - PRINCIPALLY INFECTIONS OF THE RESPIRATORY TRACT

INTRODUCTION

This large group of diseases includes those listed below. For the most part these are infections of the respiratory tract but other sites may be involved as indicated.

Infection	Infective Agent	Nonrespiratory Sites of Infection
Bacterial		
Diphtheria	*Corynebacterium diphtheriae*	Skin, myocardium, nervous system
Hemophilus influenzae infections	*Hemophilus influenzae*	Meninges
Pertussis	*Hemophilus pertussis*	
Meningitis (epidemic)	*Neisseria intracellularis*	Meninges, skin, joints
Pneumonia	*Diplococcus pneumoniae, Klebsiella pneumoniae*	Meninges, urinary tract
Staphylococcal infections	*Staphylococcus aureus*	Skin, endocardium
Streptococcal pharyngitis and scarlet fever	*Streptococcus pyogenes*	Skin
Tuberculosis	*Mycobacterium tuberculosis* (var. *hominis*)	Multiple
Leprosy	*Mycobacterium leprae*	Multiple
Viral		
Adenovirus infections ("ARD," pharyngitis)	Adenoviruses (types 1–18)	Eye, gut
Common cold	Rhinoviruses (types 1–55)	?
cough, rhinitis, and fever	Respiratory syncytial virus (CCA)	?
Parainfluenza (croup, colds)	Parainfluenza viruses 1–4	?
Influenza	Influenza viruses A,B,C	?
Mumps	Mumps virus	Meninges, central nervous system, salivary glands, gonads, pancreas
Smallpox	Variola virus	Skin, viscera
Chickenpox and herpes zoster	Varicella virus	Skin, posterior roots
Herpes simplex	Herpes simplex virus	Skin, eye
Measles	Measles virus	Skin, C.N.S. (?)
Rubella	Rubella virus	Skin, C.N.S. (?)
Primary atypical pneumonia	PPLO	?
Infectious mononucleosis	Virus?	Liver, spleen

(Source: Kilbourne)

To this list may be added the special group of venereal or sexually transmitted diseases. Among the more serious of these are Gonococcal infection and Syphilis. This group will be discussed separately later in this Section.

Respiratory diseases are probably the principal causes of morbidity and mortality - especially in the early years of life. They are transmitted from man to man by an airborne route as well as by direct contact or ingestion.

In early life, viruses play a predominant role in the initiation of respiratory infection but with the exception of viral bronchiolitis and parainfluenza, the severity and complications common with respiratory disease are mostly conditioned by secondary bacterial infection. It is thought that these bacteria are already present in the upper respiratory tract where they tend to be relatively harmless until tissue resistance is lowered by the antecedent virus infection. For this reason they are commonly referred to as potential or opportunistic pathogens.

They probably include influenza bacilli, pneumococci, staphylococci, coliform bacilli and Klebsiella.

Primary virus infections are most likely to be contracted by infants and young children in the market-place or at social gatherings. The custom of carrying the child on the back probably contributes to this. Extended families and shared households also ensure that the young child is frequently in contact with other young children and at risk of primary viral infection. Although in very young children the incidence of serious morbidity and mortality from primary viral infection can be high, more often the severity of illness - commonly bronchitis and bronchopneumonia - are caused by secondary bacterial infection from pathogens already present in the upper respiratory tract.

It is not clear from available evidence whether these infections are more prevalent in poor urban communities than elsewhere (prevalence estimates are influenced by illness reporting behaviour, availability of health services etc.) but evidence does indicate that their clinical manifestation is more severe. Whilst severity may be in part due to the late reporting of illness, it is likely also that the lower nutritional state of poor children reduces their natural resistance.

In contrast to enteric pathogens, the agents of respiratory disease cannot survive for long in the external environment. They are thus largely unaffected by environmental sanitation measures.

A key concept is to distinguish between 'serious' and 'non-serious' infections since there is a need for individuals to build up and maintain resistance. To some extent, therefore, whilst preventive methods should be applied for such serious infection, it is often a disadvantage to avoid the less serious childhood infections as contraction is the only way in which resistance can be obtained (except where immunisation is available). In any case it is highly doubtful if many airborne infections could be prevented even under the most ideal living conditions.

"Even if it were possible by ultraviolet irradiation or other means to insulate the child from contact with the causative agents of 'the diseases of childhood', such a procedure would put the child in undue jeopardy if infection were postponed until his adult years. Almost without exception, primary infections result in more severe disease in the adult than in the child. Therefore, methods of disease control that merely postpone the infection without inducing specific resistance are not only unrealistic, but dangerous." (Kilbourne 19. p.260).

The only acceptable means of control of this group of diseases are therefore:-

- to improve levels of nutrition and general well-being so that the effects of infection are less severe.

- to artificially establish immunity strough immunization.

- to provide specific drugs to reduce the severity of infection.

There remains of course a number of airborne or contact diseases that are not inevitable (or 'desirable' in the sense discussed above), and which may have serious consequences. The most important of these in Kenya are discussed subsequently under individual headings.

Before that an attempt is made to summarise something of what is known about the influence of housing conditions on the spread of airborne and contact disease in general.

Air disinfection by ultraviolet irradiation has been shown to diminish the number of airborne bacteria in schools in the UK (Air Hygiene Committee 1954). However, no decline was observed in the number of streptococcal infections.

"The methods used for the detection of airborne bacteria are more useful as an indicator of the hygienic quality of the air (Cvjetanovic 1950, Bourdillon 1948) than as an index of the actual danger of infection with pathogenic airborne bacteria." (WHO 1974 p.13).

"Numerous techniques have been used for the detection of airborne bacteria and certain minimum requirements have been proposed for dwellings and working premises, small surgeries, dressing rooms and operating theatres (Bourdillon 1946). However, it is difficult to demonstrate a direct correlation between the number of airborne bacteria and the incidence of infection." (WHO 1974 p.13).

Studies from Ghana (Waddy 1954, 1957a, 1957b) have been employed to suggest an association between cerebrospinal meningitis and housing. There, different incidence of the disease has been attributed to different forms of house construction in two areas. In particular the square mud houses of the Dagarti and Lobi tribes have been incriminated because of crowding at night, darkness and poor ventilation contrasted with round huts with thatched roofs predominant in the second area. But these conclusions do not stand up to much examination. Ellison (1979) points out that this difference may not be related to housing since tribal associations are different and this may imply differences in communication with other epidemic centres such as northern Nigeria. Different behavioural patterns could also easily explain the observed variation. Scott (1965) concluded that direct contact rather than aerosol transmission was the dominant transmission route in which case ventilation is largely irrelevant.

Cvjetanovic (1976) claims that studies from Mali and Upper Volta show the influence of housing on cerebrospinal meningitis transmission.

"There were several times fewer airborne bacteria and cases of meningitis in the modern housing scheme as compared with the traditional African suburban houses, which supports the belief that the crowded and poorly aerated mud houses are a major cause of the disasterous meningitis epidemics in Africa." p.120.

Cvjetanovic gives no reference for these studies in the text but they are assumed to refer to the work of Ghipponi (1971).

WHO (1974) also refers to these studies:-

"It was shown that in certain traditional types of indigenous house where the air-space per inhabitant was only half that available in improved houses the number of S. salivarius and Escherichia coli per unit of volume was twice as high, and the total number of bacteria nearly 10 times as high. The incidence of cerebrospinal meningitis was 5-10 times as high in the poor houses as in the improved ones." p.14.

In fact, however, this is not the whole story. Ghipponi (1971) reports a series of measurements. Firstly, he could detect no difference in aerosol counts of streptococci and coliforms between well ventilated round houses and the flat roofed, poorly ventilated ones. He did find, however, lower counts in round houses with concrete floors suggesting perhaps that these organisms may persist in soil. But as Ellison (1979) points out, this may not be the case for meningococci. In the urban areas where Ghipponi did further studies, again higher counts were obtained in the huts with dirt floors than in the houses with concrete floors and generally of a higher standard. However, the two types of houses are of course occupied by two different socio-economic groups which fact may have more influence on indicator bacteria counts than does the quality of the floor. Certainly, however, it is difficult to conclude from these studies anything about ventilation!

Poor quality housing has been associated with a higher incidence of tuberculosis but it is invariably also associated with poor nutrition and a lack of hygiene - factors that are known to predispose to tuberculosis.

It has been experimentally demonstrated that a single Mycobacterium tuberculosis organism inhaled in a droplet nucleus can produce a primary infection (Lurie 1950) so that it is highly unlikely that members of a household will avoid infecting each other in any housing at any levels of space standards.

Studies of the natural behaviour of airborne microbes causing disease are inconclusive and complicated by the fact that air is rarely the only route by which such pathogens can spread. Measures of the density of airborne pathogens and dose-effect relationships are complicated by numerous host factors.

Room sizes probably bear little relationship to the degree of transmission (Hughes 1951). Studies of the movement of tubercle bacilli indicate that a single highly infectious case can disseminate some sixty infective particles per hour giving a concentration of one infective particle per $6m^3$(Rilgey 1962). These extremely small particles can remain airborne for considerable times. Studies in factories indicate that a single infective person is a risk to all other people working in the same space no matter how large the room (Hughes 1951). Studies of staphylococci infection in surgical wards found little difference in the rate at which patients in beds at various distances from the carrier acquired staphylococci (Williams 1967).

However, this may not be true of all airborne bacteria and there is evidence that the acquisition of streptococci declines with increasing physical separation (Wannamaker 1954). The most straightforward possible explanation for these differences is that of a large variation in the size of particles or droplets and therefore in the times for which they are likely to remain airborne. Many of the larger particles do require very close contact for transmission.

In general, then, airborne and contact infections are only in small part facilitated by housing itself. Far more important is the way of life in the house and outside, the intensity of human contacts, family size and the number of introductions of infection to the household etc.

With many infections, it is doubtful whether people living in normal close contact can avoid infecting each other regardless of housing quality or space per person. In large families with frequent social intercourse there are so many other opportunities for the spread of infection.

Similarly with ventilation:-

"The latest hey-day of airborne infection was ushered in by Wells, in the 1930's, who looked to a development of 'sanitary ventilation' that would eliminate respiratory tract infections in the way that purification of drinking water has virtually eliminated the enteric fevers. That this hope remains unrealized is presumably because so few of the respiratory diseases are like tuberculosis in apparently requiring deposition of the microbe in the lung alveoli, and which, therefore, can be conveyed only by the very small proportion of 2-3 micron particles that are liberated during coughing and other expiratory activities. No dramatic control of the spread of the larger, shorter-range droplets could be expected from any of the methods of air sanitation in common use, and none has been observed. Some effect might be expected with the particles of intermediate size and there are some hints that streptocóccal infections (Med. Res. Council, 1954) and staphylococcal infection (see Williams, 1966) may be affected to some extent. But it appears that with most of the infections we encounter, transfer by routes susceptible to 'sanitary ventilation' constitutes only a small part of all the transfer that takes place and the reduction in dosage that we can achieve in practice is often too small to have a detectable effect on the incidence of infection." (Williams 1967, p.282).

SUMMARY

Whilst larger room sizes and improved ventilation may be desirable qualities of low-cost housing, it is not possible to demonstrate a decisive association between them and improved health and it is certainly not possible to use health considerations in a quantitative way to establish minimum physical dimensions or requirements for these housing factors.

Probably the most important influence on the high prevalence of respiratory infections is the overcrowding associated with large extended families and multiple households. Such overcrowding and close physical lifestyles (e.g. bed sharing) present many opportunities for transmission of airborne infection as indeed do social events outside the household - crowded buses and matatus, markets etc.

Host factors - particularly nutrition and general well-being - probably play a decisive role in the severity of childhood respiratory diseases many of which are inevitable. Measles is the best studied example of this.

In short, housing offers few specific interventions with which to reduce the incidence of respiratory disease.

Improvement may come about through rising socio-economic conditions at least through the beneficial effect on nutrition and through the utilisation of more readily available health care services that should accompany new housing developments.

Moreover, better housing services like water and sanitation may - if accompanied by corresponding improvement in socio-economic standards - achieve a reduction in the enteric infections that are a major factor in provoking low nutrition and increasing the seriousness of much respiratory disease.

New housing developments provide the opportunity for organised and effective preventive and curative health care and this is very relevant to respiratory infections. Newly housed families should be strongly encouraged to accept appropriate immunization for all family members. From the list of respiratory diseases given earlier, immunization is available for:-

Diphtheria
Pertussis
Tuberculosis
Measles

TUBERCULOSIS

NAIROBI	
THIKA	
NAKURU	
MACHAKOS	Not possible to relate specifically to project sites. Cooler, dry areas are thought to have higher prevalence (e.g. Meru, Machakos, Nakuru, Nairobi, Thika) but this study found high rates at Lamu.
ISIOLO	
MERU	
MOMBASA	
LAMU	
KAKAMEGA	
WEBUYE	
KISUMU	
KAJIADO	

TUBERCULOSIS

Tuberculosis has been one of the greatest health problems in Kenya - as indeed in many other parts of the world.

In 1963 it was estimated (on the basis of a national survey undertaken in 1958-59), that about 110,000 of the (then) 6m population had tuberculosis of whom 40% represented a source of infection. About 38,000 were under 5 years of age.

BCG vaccination programmes were introduced in the early 1960's and during 1962-69 some 3.7m children under 16 received vaccinations. By 1973, a further 2.9m doses were administered and this programme has been continuing. It seems likely that in the coming years all Kenyan children will receive BCG vaccination and, if this programme can be maintained, tuberculosis will be well under control.

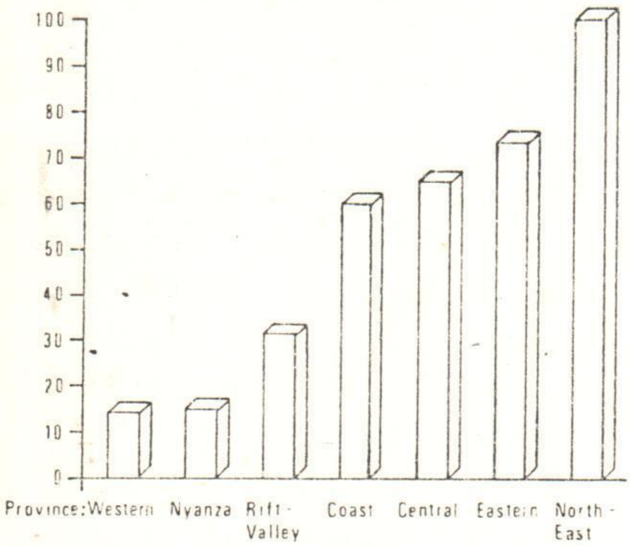
With regard to housing implications, most of the general comments about respiratory disease apply. Infection is introduced frequently by adult males who themselves acquire the infection at work. In households with such an infective member it is highly unlikely that other family members, particularly young children, will not become infected no matter what housing standards they live under.

Apart from effective BCG programmes that most effective control of tuberculosis relies on finding more infectious cases and on finding them earlier. Tuberculosis control is thus very much in the hands of the health authorities but public education to encourage reporting is also a vital component.

Modern therapy for tuberculosis is completely effective and it is worth noting that once a diagnosis has been made and a patient put on chemotherapy, there is no risk of infection to close family contacts from treating even heavily sputum-positive patients at home even under the most unfavourable living conditions and gross overcrowding. Chemotherapy renders patients non-infectious extremely rapidly.

However, therapy can only be effective if the course of drugs is completed. There is great temptation for patients on therapy to discontinue drug regimens as soon as the main symptoms of the disease disappear. This can create very serious drug resistance problems and there is evidence that this is now occuring in Kenya.

It is difficult to comment meaningfully on the national distribution of tuberculosis. However, statistics do indicate higher frequencies in cooler, dry areas than in humid-warm or dry warm regions. This is reinforced by the data below taken from Diesfeld (1978).



Pulmonary Tuberculosis

Rate per 100,000 population of the median year 1969 compiled for provinces from 35 districts for the year 1962–1972 from Weekly Notifications of infectious Diseases, Ministry of Health, Nairobi

Tuberculosis is also associated with poor nutrition and with low standards of personal hygiene and it is, therefore, probable that higher prevalence is found in poor communities.

By bringing such populations more under the control of authorities, new housing developments provide excellent opportunities both for BCG vaccination and for case-finding and family follow-up.

CEREBROSPINAL MENINGITIS

NAIROBI		
THIKA	*	
NAKURU		
MACHAKOS	*	Not possible to relate specifically to project sites since outbreaks have been in clustered foci.
ISIOLO	*	
MERU	*	
MOMBASA		
LAMU		
KAKAMEGA	*	
WEBUYE	*	
KISUMU	*	
KAJIADO		

* areas of probable higher risk

CEREBROSPINAL MENINGITIS

An acute bacterial disease. Agent *Neisseria meningitidis*.

It was previously thought that Kenya was fortunately not part of the 'meningitis belt' - a broad east-west region covering the Sahel through to Sudan (Waddy 1954, 1957(i), 1957(ii), Scott 1965). However, that view may now be due for revision.

There have been small outbreaks in Kenya over recent years but these have so far tended to occur in clustered foci including some urban areas.

The disease occurs mainly in the dry winter months and tends to cease quite abruptly with the rain season.

Highest reported rates have come from the Central Province and these are at least twice as high as those from Eastern, Eastern-Rift Valley and Western Provinces. Although sometimes reported elsewhere, incidence is significantly lower.

Survival time outside the body is very short so that close contact is required for transmission. Infected cases become carriers and can remain so for many months. The disease only manifests in one out of several hundred infected individuals.

There has been much controversy of the role of housing in transmission (see the introduction to this Section on Airborne and Contact Diseases). The evidence is inconclusive but on balance indicates that is probably more crowding, social and family behaviour etc. (e.g. bed-sharing especially by children) rather than the house that promotes transmission.

NAIROBI		
THIKA		
NAKURU		
MACHAKOS		
ISIOLO		
MERU	*	Highest prevalence occurs in areas of western Kenya (especially Kisumu), Mombasa and eastern Meru.
MOMBASA	*	
LAMU		
KAKAMEGA	*	
WEBUYE	*	
KISUMU	**	
KAJIADO		

LEPROSY

Leprosy is still a serious problem in Kenya. Estimates have put the number of cases between 35,000 (Fendall and Grounds 1965) and 60-70,000 (Verhagen 1974). Specific foci occur in the following areas.

Western Kenya: Kisumu, Busia and Bungoma Districts display the highest infection rates in the country (1-3%).

Coastal area: variable frequency but probably highest in Kilifi and Kwale Districts. Significant notifications occur in Mombasa also.

Taveta area.

Central Kenya: foci with frequency rates of 1% or greater occur in Kitui District, Embu District and in the east of Meru District.

Leprosy appears to be much rarer in the Central Highlands and Rift Valley Provinces.

The disease is not particularly well understood in very many aspects. It is thought that transmission occurs mainly through nasal discharge from infected cases gaining entrance through the skin or respiratory tract. Whilst household contact is obviously important, there is little that housing can do to reduce transmission rates.

Treatment is effective and the control programme is now well advanced.

MEASLES

NAIROBI		
THIKA	*	
NAKURU		
MACHAKOS		Although Mombasa reports lower rates, it seems likely that poor communities are especially affected wherever they are.
ISIOLO	*	
MERU	*	
MOMBASA		
LAMU		
KAKAMEGA		
WEBUYE		
KISUMU		
KAJIADO		

* higher reporting rates for measles and kwashiorkor

Measles is an acute, highly communicable viral infection.

It provides one of the best-studied examples of the way in which the seriousness of infection is related to nutritional status (Morley 1973,1976, Forbes 1973).

It also provides a good example of an inevitable childhood disease (as discussed in the introduction to this Section on Airborne and Contact Diseases) that, in disadvantaged nutritional conditions, is too serious to be left to a natural course of immunity. Natural resistance will be achieved, of course, in those infants who survive but mortality rates are high and because of its two-way relationship with nutrition, measles brings serious sequelae including respiratory complications, diarrhoea, weight loss and hence further nutritional decline and lowered resistance to other infection.

Case-fatality rates have been estimated as being of the order of 400 times higher for children in poor communities than for those in good ones (Pan American Health Organisation 1973).

Two main factors explain this: the earlier age at which measles typically develops in poor communities and the low nutritional states prevalent there.

Morley (1976) reports examples of the mean age of infection as 24.7 months for Ghana, 18.0 months for Jordan, 29.7 months for Zambia, Tanzania and Rhodesia, and peak incidence from Nigeria at 12-18 months with over 30% incidence at under 12 months. In Kenya, Muller (1977) has suggested that previous estimates for age specific incidence have been, in fact, too low as findings have been based on hospital outpatient figures rather than all cases - the implication being that hospital cases are the more serious ones and these are likely to be the younger ones thus distorting the figures downwards. Muller's studies in Machakos (Muller 1977) found that the median age was 32 months but with 15-19% at less than 12 months and with about

8-9% less than 8 months.

All this contrasts with the median age of 51.7 months for the U.K. (1966).

Of course, the lower age specific incidence of measles and the seriousness of the infection in lower nutritional states are related factors. Children are growing faster at lower ages - or should be - and this is when malnutrition is most likely to occur.

The typically lower age for infection has been attributed to the many more opportunities offered for infection in poor communities. These include the practice of mothers carrying infants (on the back) to markets and social events etc. and to extended families and shared households.

Measles - or at least severity - is therefore in many ways a disease of poverty. Given that close physical proximity is inevitable in such circumstances, there is little that housing can do specifically to reduce transmission risks. However, measles is an important example of a general principle discussed early of where although housing offers little specific intervention potential, improved housing can make a contribution to raised standards of living and therefore to nutrition. It also provides increased control over and access to populations and thus allows organised immunisation campaigns. These are not cheap with measles and have their difficulties (Hendrickse 1975, England 1978) but at least in controlled new urban communities, they are likely to be cost-effective.

Consistant with the inter-relationships with nutrition noted above, the distribution of measles in Kenya (of cases sufficiently serious to appear in hospital records) shows a correlation with that for kwashiorkor (Diersfeld 1978).

Medium-to-high reporting rates for measles and high kwashiorkor occur in Thika, Meru and Isiolo.

Medium rates for measles and kwashiokor are reported in Kakamega, Kisumu, Nairobi, Lamu, Nakuru and Machakos.

Low rates are reported from Mombasa.

It is worth noting that an interesting phenomenon is now occuring in Mumias where malnutrition has recently risen rapidly (personal observation; no studies are reported). The development of a large sugar processing works has encouraged almost all small farmers around the town to turn to sugar growing. Although families now have more cash as a result, the inflationary effects on basic food produce is having serious consequences for protein-calorie intake.

TRACHOMA AND INFECTIOUS EYE DISEASE

NAIROBI		
THIKA	*	
NAKURU		
MACHAKOS	*	Largely confined to northern, eastern and some central areas.
ISIOLO	*	
MERU	*	
MOMBASA		
LAMU		
KAKAMEGA		
WEBUYE		
KISUMU		
KAJIADO		

* higher reporting rates

TRACHOMA AND INFECTIOUS EYE DISEASE

Trachoma and other infectious eye diseases display a high prevalence but with quite distinct regional variations.

The greatest frequency of reporting occurs in the north and north-east of the country (including Isiolo and Meru). Lower but significant reporting occurs in central areas and the southern Rift Valley (including Thika and Machakos). Coastal and western areas have very low reporting rates.

Trachoma is transmitted by direct contact with ocular discharge and may be assisted by flies. It mainly affects children.

Risk factors associated with transmission are thus insanitary habits, overcrowding, absence/lack of clean washing water, and large fly populations. The most important of these is water supply. As soon as this is available and used for regular face washing, the incidence of trachoma declines rapidly.

Logically, trachoma is primarily a disease of dry regions.

The implications for housing are obvious. Opportunities are required for regular washing and this is far better achieved with individual plot connections than with community standpipes or central water selling points. Trachoma thus shares with enteric infections, skin and other eye diseases the need for adequate household water supply if significant improvement is to be achieved. Any new housing which provides this at affordable levels will gain a tremendous advantage over the inadequate water supply arrangements typical in the urban slums.

3. EXCRETA-RELATED DISEASES

For the most part, these are enteric infections in which the parasite concerned invades and multiplies in the human gut. Many such infections are acquired by ingestion. Many are able to survive and some to multiply outside the human host requiring no intermediate host in which to do so. However, whilst some of these infections do not conform to these generalisations, all are related to human excreta.

The discussion in this section relies heavily on the recent World Bank publication "Health Aspects of Excreta and Waste-water Management" (Feachem *et al* 1978). This publication provides the most useful single collection of background information available on the behaviour and survival characteristics of the major excreta-related disease agents relevant to possible environmental interventions.

Detailed discussions and bibliographies are provided under the following headings:-

EXCRETED VIRUSES

Enteric viruses, poliomyelitis and similar viral infections.
Hepatitis A virus and infectious hepatitis.
Viral gastro-enteritis.

EXCRETED BACTERIA

Campylobacter and *Campylobacter* enteritis
Escherichia coli and gastro-enteritis.
Faecal bacteria indicator organisms.
Leptospira and leptospirosis.
Salmonella, enteric fevers and salmonelloses.
Shigella and shigellosis.
Vibrio cholerae and cholera.
Yersinia and yersiniosis.

EXCRETED PROTOZOA

Balantidium and balantidiasis.

Entamoeba histolytica and amoebiasis.
Giardia and giardiasis.

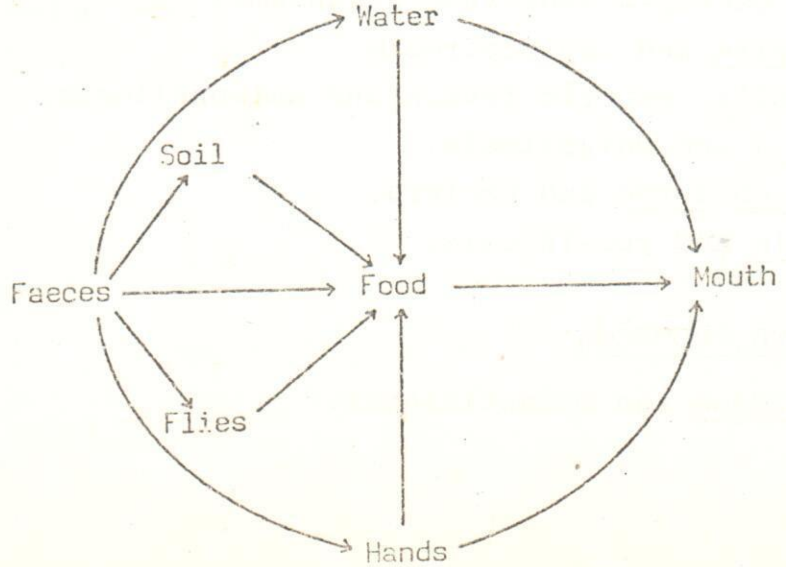
EXCRETED HELMINTHS

Ancylostoma and ancylostomiasis.
Ascaris and ascariasis.
Clonorchis and clonorchiasis.
Diphyllobothrium and diphyllobothriasis.
Enterobius and enterobiasis.
Fasciola and fascioliasis.
Fasciolopsis and fasciolopsiasis.
Hymenolepis and hymenolepiasis.
Minor Intestinal flukes.
Paragonimus and paragonimiasis.
Schistosoma and schistosomiasis.
Strongyloides and strongyloidiasis.
Taenia, taeniasis and cysticercosis.
Trichuris and trichuriasis.

Here we discuss briefly only those of major relevance to Kenya.

For the most part these excreta-related viruses, bacteria and protozoa display similar transmission behaviour although, of course, their precise characteristics and survival rates differ.

In very general terms, the variety of transmission routes available to this group of infections (excluding helminths) can be summarised as follows:-



The various pathogens concerned display different preferences within these available routes although these are not always well understood. Nevertheless, it is clear that if attempts to break these transmission routes are successful, they are likely to reduce the incidence of several infections.

The following sub-sections discuss some of the specific infections of major importance. However, it is a fact that much enteric disease cannot be satisfactorily attributed to specific disease agents. This is particularly the case with diarrhoeal disease affecting infants and children and this is discussed first.

NAIROBI	
THIKA	
NAKURU	
MACHAKOS	No regional differentiation possible. All poor communities are at high risk and there are special risks for infants.
ISIOLO	
MERU	
MOMBASA	
LAMU	
KAKAMEGA	
WEBUYE	
KISUMU	
KAJIADO	

ACUTE UNDIFFERENTIATED DIARRHOEAL DISEASE

This category covers a wide range of diarrhoeal diseases of diverse and frequently unidentifiable etiology. It may include specific infectious diseases like cholera, shigellosis, salmonellosis, amoebiasis, E. Coli, or acute viral gastroenteritis but may equally be caused by other viruses, protozoa or helminths. Multiple infection and concurrent disease may be common.

Virus involvement in acute diarrhoeal disease is particularly complicated.

This complex of infections is particularly important in the way and extent it affects infants and very young children particularly during weaning. In areas of low hygiene standards 'weanling diarrhoea' is extremely common and is intimately related to nutrition. Sub-nutrition predisposes to attack whilst the infection itself further reduces nutritional status sometimes resulting in severe malnutrition and growth retardation. Case-fatality rates in infants in poor areas can be extremely high. Infant gastroenteritis represents something like 60-70% of all infant deaths in Kenya (and 80% of deaths of all ages from gastroenteritis).

The high incidence of this disease in poor communities is most easily attributed to the unhygienic conditions in which infants must be fed - with little or no opportunity to sterilise feeding utensils or to boil water etc. There is dramatically higher prevalence among artificially-fed than amoung breast-fed infants. One important control intervention is, therefore, to encourage breast feeding in communities with little hope of achieving sufficiently hygienic conditions for artificial infant food preparation. This implies a serious commitment on the part of the health authorities to combat the commercial advertising drive to promote artificial infant feeding products - a serious problem in many urban areas where artificial feeding has been 'successfully' associated by advertising with increasing modernisation and social status.

Of course, weaning has to occur at some age and although the health risk may reduce with time, it by no means disappears. As far as urban housing programmes are concerned, therefore, a major contribution to control of infant gastro-enteritis can be achieved through the provision of suitable household water supply combined of course with its effective use.

Health services have a major role to play in deprived communities through the early and effective rehydration of affected infants followed by rapid resumption of adequate protein-calorie intake as soon as diarrhoea has been controlled. Maternal education through well-mother-and-child clinics is probably the most cost effective health services intervention providing, as it does, opportunities for early detection, nutrition education and of course opportunities for preventive measures and immunization for many other diseases.

NAIROBI	
THIKA	
NAKURU	
MACHAKOS	No meaningful regional variation possible.
ISIOLO	1960 epidemic was centered on Nairobi, Central and Rift Valley Provinces but all areas are at risk.
MERU	
MOMBASA	
LAMU	
KAKAMEGA	
WEBUYE	
KISUMU	
KAJIADO	

POLIOMYELITIS

Poliomyelitis is probably the most important of the large group of enteroviruses including coxsackie and echo. Its behaviour is generally regarded as being typical of these other viruses in most respects.

Clinical poliomyelitis develops in a very small proportion of people infected - perhaps only 1 or 2%. But infected persons can shed large number of viruses in faeces. Transmission is mainly by a faecal-oral route but also by oral-oral routes. It is probable that child-to-child transmission introduces the disease into new family groups. Children are the most susceptible age group since most adults have acquired resistance during earlier infection.

In areas with poor hygiene children frequently acquire immunity whilst very young. The severity of the disease is very dependant on age and young adults who have not gained immunity show the most serious symptoms including, frequently, paralysis.

Rising standars of hygiene, therefore, risk delaying infection until later in life with very serious consequences. The only satisfactory control of poliomyelitis is therefore vaccination since no specific treatment is available.

The 1960 polio epidemic in Kenya clearly reflected this link with rising standards. The numbers of reported cases were higher from Nairobi, Central and Rift Valley Provinces than from Western, Northern and Southern Provinces.

INFECTIOUS HEPATITIS

NAIROBI	*	
THIKA	*	
NAKURU		
MACHAKOS		
ISIOLO		Much higher (x10) frequency of reporting from Coast Province.
MERU		
MOMBASA	***	
LAMU	***?	
KAKAMEGA		
WEBUYE		
KISUMU		
KAJIADO		

INFECTIOUS HEPATITIS

(Hepatitis A)

Again, severity tends to increase with age. Many cases are mild especially in children. Precise incidence and distribution is difficult to establish because of the high proportion of sub-clinical infections.

Transmission occurs by the faecal-oral route most commonly by person to person contact. Food and water borne outbreaks also occur.

Transmission is therefore most likely to be interrupted by a combination of:-

- sanitary excreta disposal
- household water supply for hand washing after defaecation
- more hygienic behaviour
- adequate sewage treatment

Analysis of the Weekly Notifications of Infectious Diseases indicate that by far the highest reported frequency of hepatitis comes from the Coast Province followed by Central Province, Nairobi and North East Province. Reported frequency at the coast was ten times higher than that for Central Province.

SALMONELLOSES - INCLUDING TYPHOID

Salmonellosis is an infection of the bacteria Salmonella, forms of which (S. typhi and S. paratyphi) are the causative agents of typhoid and paratyphoid.

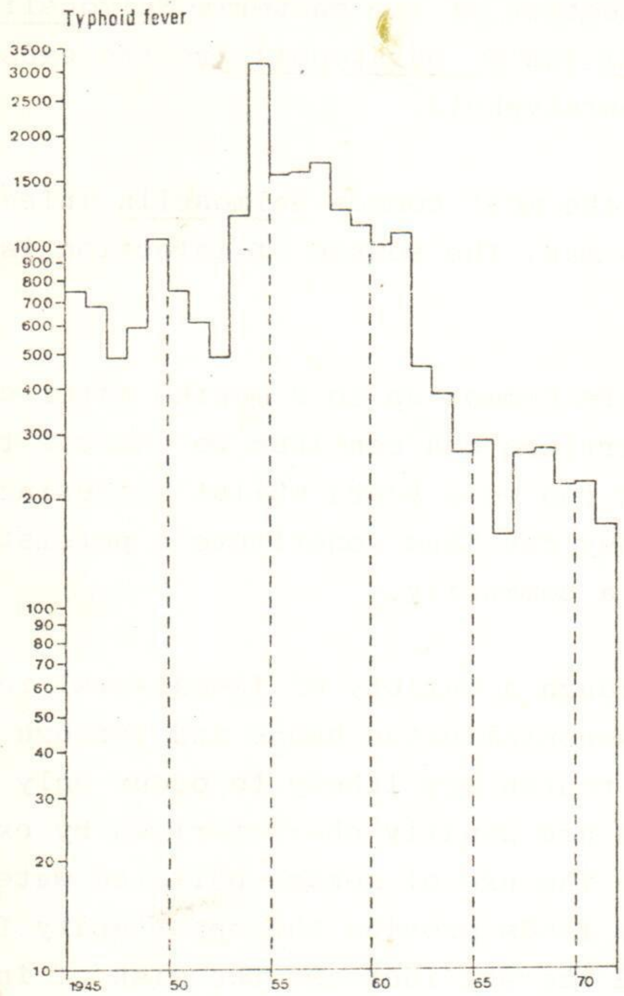
Typhoid remains one of the most common Salmonella infections. Since it is confined to man, the source of infection is the human case or carrier.

Convalescent carriers are common up to 3 months after clinical recovery but chronic carriers can continue to excrete typhoid bacilli for many months (up to a year) whilst suffering no diarrhoeal disease. They can thus constitute a persistant source of infection in a community.

Transmission occurs through a variety of faecal-oral routes both directly by faeces-contaminated hands and through food and water. Waterborne routes are likely to occur only through gross contamination and are usually characterised by explosive outbreaks often through the use of sewage-polluted water in food preparation. Many foods provide the opportunity for typhoid to multiply and thereby increase the risk of infection.

Little is known about the distribution of the infection in Kenya. It can only be assumed to be an ever present risk - see table. Kwamina Duncan (1978) reports that of stool cultures done at Kenyatta National Hospital Laboratories from 1972-1976, 58% of positive findings for Salmonella were for children under 5 years.

"The distribution of these bacterial infections (Salmonella and Shigellae) are known to be concentrated at different foci in shanty areas within and in fringe and peri-urban locations of Nairobi. Houseflies abound in these areas and they are principally implicated in the transfer of Shigella sp. Domestic animals like fowl, goats and sheep contribute to the spread of Salmonellosis." (Kwamina Duncan 1978).



Typhoid - number of annual notifications 1945-1972

Source: Fendall and Grounds, 1965;
Bulletin of Infectious Diseases, MOH 1962-1972.
Taken from Diesfeld, 1978.

Certainly, the rapid growth of the insanitary urban slum areas must increase the possibility that latent infection levels will remain sufficiently high for outbreaks to occur.

The most important housing intervention is likely to be the provision of a water supply suitable for personal hygiene. At the same time, however, community water supplies must avoid risk of contamination from faulty excreta disposal and treatment. There are therefore, obvious dangers in the informal water supply arrangements common in the self-settled urban slums particularly where self-connections and intermittent supply occurs in soil conditions contaminated by ineffective excreta disposal.

SHIGELLOSIS

Shigellosis is an acute diarrhoeal disease caused by bacteria of the Shigella genus. Its severity is conditioned by nutritional states and age of those infected. Amoungst the many serotypes the group Shigella dysenteriae produces the most severe form of disease - bacillary dysentery. For all practical purposes, man is the most effective source of infection.

The highest incidence occurs in children aged 1-4 years and the disease is invariably endemic wherever poor housing, low nutrition, overcrowding and inadequate hygiene are found.

In a study of the results of stool cultures done at the Kenyatta National Hospital Laboratories during 1972-1976, Kwamina Duncan (1978) reports for Shigella sp. that 58.8% of positive findings were from children under 5 years.

Bacillary dysentery is primarily an epidemic disease but often occurs endemically. Transmission is by a direct faecal-oral route but also food, in which Shigella are able to multiply, can easily be contaminated by fingers of infected cases or carriers. Water borne outbreaks are also possible. Flies are implicated in mechanical transmission from one place to another (e.g. excreta to food). However, the predominate mode of transmission appears to be faeces-hands-objects (especially in and near excreta disposal facilities) - hands-mouth.

Hands become contaminated during anal cleansing and the immediate area of the toilet itself becomes contaminated during the passing of stools. Although use of toilet paper is probably the most hygienic form of anal cleansing, bacteria organisms can easily pass through paper to hands. Thus toilet flushing arrangements, door handles etc. easily become contaminated. The infective dose for Shigellosis is small.

A small proportion of symptomless cases can continue to excrete shigellae thus continuing the endemic state of the disease unless transmission is effectively interrupted. But by far the most dangerous source of infection is the acute clinical case.

Principal housing interventions are therefore:-

- household water supplies to facilitate regular hand washing. To be really effective in interrupting Shigellae, transmission (and indeed other enteric infections), hand washing should occur after every toilet contact and toilet surfaces should be regularly cleaned.

- excreta disposal that ensures the safe removal of excreta avoiding ground or water supply contamination and that denies access to excreta by flies. Toilet design and materials should be convenient to clean and should avoid possibilities for excreta contact with soil.

It is important to emphasise that it is unlikely that great improvement would be achieved with the provision of sanitary excreta disposal alone. Excreta-hand transmission would still occur. Household water supply combined with hygienic personal behaviour are probably the single most effective intervention.

It is also noteworthy that improved excreta disposal does not automatically require cistern-flush, 'modern style' toilets. These and the artifacts of their superstructure can become as easily contaminated as many other cheaper arrangements.

CHOLERA

Cholera is a bacterial infection caused by Vibrio cholerae which exists in the two forms of classical and El tor. El tor appears to have become more important in the more recent outbreaks around the world and appears to display a higher proportion of mild and symptomless infections than the classical type.

In areas where cholera is endemic, it develops a regular periodicity and epidemic waves occur seasonally.

Cholera is confined to man and the source of infection is therefore the human case and carrier. It displays a high rate of subclinical infection and this, combined with short-lived immunity and a small number of chronic carriers, ensures its endemic maintenance. Even in severe epidemics clinical attack rates are thought to be only 1-2% of the population although inapparent infection rates are much higher.

Transmission has historically been assumed to occur via a water borne route and explosive epidemics certainly occur when a common water source is contaminated. However, there is some more recent evidence that transmission can occur by close personal contact. V. cholerae has been detected in water tanks in the vicinity of carriers and there is evidence of continuity of infection within households. It may be that the El tor type is more resistant to adverse environmental conditions and is less dependent than the classical strain on water as a transmission vehicle. For practical purposes water, food and personal contact can be considered possible transmission routes. The carrier state probably ensures an adequate human reservoir of infection in endemic areas so that transmission can continue largely in a symptomless form.

Cholera is primarily a disease of poor socio-economic groups presumably because of the association with poor environmental sanitation and hygiene but perhaps, since in areas where it is endemic it is predominantly a disease of childhood, also because of the association with large family size. The most simple explanation, however, is probably the association of poor socio-economic groups with poor quality water supplies and poor hygiene standards.

Active immunization, although available, is of relatively little value as a practical control measure as it provides only partial immunity for a very limited time period.

Cholera has not been a mjor problem in Kenya in recent times. Probably the most important outbreaks have been:

- 1971-73 several outbreaks in the north and north east
- 1975 Nyanza (shown to be mainly a rural disease there)
- 1977-78 some outbreaks on the coast including areas within Mombasa.

These were mainly of the El-tor-Inaba strains.

The risk of cholera should always be considered in poor communities even where it is historically rarely reported. Introduction into areas with poor sanitation and hygiene (e.g. the self-settled urban slums) would bring very high risks of widespread outbreak. Such outbreaks have to be attacked quickly and strongly to avoid the creation of scattered foci which then become difficult to control and eradicate.

Housing interventions of major importance include the provision of uncontaminated water supplies (preferably to the house), sufficient in quantity to facilitate regular hand-washing after daefecation and before eating and handling food. These are certainly necessary conditions for the reliable control of transmission, but sufficiency will depend on their use.

Uncontaminated water supplies depend on safe excreta disposal by a technology appropriate for the circumstances.

AMOEBIASIS

Amoebiasis is a protozoal infection of the large intestine caused by Entamoeba histolytica. The term amoebic dysentery is commonly used for the infection and although other protozoa may be present in such a diagnosis, Entamoeba histolytica is the predominent and probably the only pathogenic agent. Asymptomatic carrier states are probably very common in endemic areas. Whether or not active invasion occurs may be (partly) dependent on nutrition, alcohol and the presence of other parasites.

Transmission occurs when the Entamoeba histolytica cysts produced in the lower large intestine are ingested. Little further maturation of these cysts takes place after they have been excreted. They continue to be excreted as long as a chronic infection is present in the gut. Several transmission routes appear to be available for the cysts. These include via a water-borne route, via food contaminated by the hands of infected persons during food preparation (cysts can remain viable for 5 minutes on the skin and for 45 minutes under fingernails), and also by direct faecal ingestion from contaminated hands. Flies may also assist in spreading contamination since they can harbour viable cysts which can be excreted on food. It may be noted that cysts can survive in water for several weeks and that normal chlorine levels in water supply have no effect.

A recent study in metropolitan Lagos (Oyerinde and Alonge et al, 1979) examined stool samples from 2825 persons in 10 survey areas. They found an overall infection rate of 11.2% but varied between ethnic groups from 0% to 25%. A rate of 18.4% was found for people who had lived in the city continuously for more than 8 years - declining systematically down to 5.2% for those of less than 1 year residence.

Significant associated variables included whether people ate with hands or cutlery (11.9% as opposed to 6.8%); whether people ate frequently outside the home or not (12.1% as opposed to 6.5%); whether people used water for anal cleansing or toilet paper (14.6% as opposed to 9.9%). Occupational groupings reflecting degree of interaction showed higher rates where interaction was high (17.9% for semi-skilled down to 10.5% for housewives and 6.7% for unemployed). No association was detected with formal educational standards and little conclusive association was found with source of water (12.4% for those with house tap water; 10.9% for those who carried and stored water) with the exception of those who used well water - 23.4% prevalence.

Little association was detected between infection rates and type of sanitation. Rates of 10.7% were found for those using water closets as opposed to 12.1% and 13.4% respectively for those using buckets and pits.

Climate was an important factor with a pronounced peak at times of simultaneous high temperatures and humidity. This might be accounted for by higher cyst survival rates in such conditions and/or higher fly populations.

Little is known about the precise prevalence of amoebiasis in Kenya. In a survey of Nairobi schoolchildren (Wijers 1972), 15.7% of stools examined had Entamoeba histolytica but there is no reason to think it should be any more prevalent there than elsewhere. This survey discovered intestinal protozoa of one kind or another in 75.6% of cases.

Annual Hospital Returns for the period 1962-1973 showed more frequent reporting under the general diagnosis 'amoebic dysentery' from the uplands than elsewhere. Climatic considerations would, however, suggest higher risk in coastal and western areas.

In an analysis of stools examined at Kenyatta National Hospital 1972-1976, Kwamina Duncan (1978) reports on the importance of amoebiasis. From a total of 131,993 stool examination taken from patients with clinical diagnosis relating to the gastro-intestinal tract or to anaemias, 33.4% were positive for some form of amoebiasis (including Entamoeba histolytics, Entamoeba coli etc.).

Stool examinations from road workers in Kwale District (Brooks 1979) gave 29% positive for Entamoeba sp.

Again, appropriate housing related interventions are household water supply and excreta disposal. It is worth noting here that, as with some other infections in this broad group, it is probably only piped water to individual houses that will constitute an effective intervention. There is a lot of evidence that where water is centrally collected and then stored in the household, many opportunities occur for contamination with Entamoeba histolytica. Also, the small amounts of water possible to carry to the house from kiosks and standpipes is never sufficient for effective personal hygiene.

Excreta disposal systems must prevent any possibility of polluting water sources or the distribution network on a community wide scale. At the household level, excreta disposal facilities and the materials of which they are constructed should be such as to minimise fouling, to facilitate cleaning and to avoid access by flies.

Househld piped water and its use in regular handwashing after toilet contact will greatly assist in reducing opportunities for ingestion of cysts but in view of the continuing output of these agents from infected individuals, dramatic improvement is not likely to be achieved rapidly. Also many opportunities will remain for infection from outside the family especially from vegetables that have been in contact with polluted water.

Amoebiasis control will probably be most effectively achieved when the above measures coincide with high coverage treatment of infected individuals. Chemotherapy is very effective providing opportunities for reinfection are being diminished by sanitary measures and improved personal hygiene.

Finally, as with many other excreta related infections, effective solid waste disposal can be employed to reduce fly populations in housing areas and thus reduce their contribution to transmission.

GIARDIASIS

Giardiasis is a protozoal infection of the small intestine.

It is particularly prevalent in the 6-12 age group wherever poor sanitation and low quality water supplies are found. It is probable that man is the only host.

Transmission occurs largely as with amoebiasis but giardiasis is probably better able to survive in the environment. Transmission is, therefore, by faecal contamination of food, hands and water supply and perhaps assisted by flies. Transfer by contaminated hands is probably more likely than with amoebiasis.

Housing interventions - as for amoebiasis.

Helminths are parasitic worms which may invade man by a variety of routes and inhabit various areas of his body including the digestive tract, liver, lungs and blood vessels.

Some are transmitted from man to man directly, some via soil, and some via an intermediate host. From amoungst the long list of helminths, those of major relevance in Kenya are discussed individually.

In addition to these, Filariasis (Wuchereria bancrofti) and onchocerciasis are helminths but neither are related primarily with an excreta-borne route (though the vector of Filariasis, Culex fatigans, does breed in latrines etc.) and are considered under the category arthropod-borne diseases.

Except for Strongyloides, helminths do not multiply in man. The worm load carried can only be increaed by additional infection. The seriousness of helminthic infection is, therefore, largely related to the quantitative infective load carried. More serious infestation usually results from the cumulative effect of constant reinfection over long periods. This contrasts with the asexually reproducing organisms of viruses, bacteria and protozoa.

NAIROBI	40%
THIKA	25%
NAKURU	45%
MACHAKOS	54%
ISIOLO	60%
MERU	65%
MOMBASA	45%
LAMU	72%
KAKAMEGA	55%
WEBUYE	45%
KISUMU	50%
KAJIADO	44%

Figures show best estimates for site specific relative frequency of positive ascariasis findings from Annual Laboratory Returns 1958-1973.

ASCARIASIS

- roundworm

Ascariasis is a helminthic infection primarily of the small intestine by the roundworm Ascaris lumbricoides. Most infections are in fact more or less symptomless but even a small worm load can be serious. Serious complications can occur especially in children and include bowel obstruciton or death resulting from migration of the adult worm to the liver, gall bladder, appendix etc.

In general,ascariasis infection rates are highest in children. One of the major consequences of the disease is nutritional deficiency. A comparatively small infective load can reduce the effective daily protein intake considerably and in areas where this is already marginal, this can have very serious repercussions.

The transmission cycle starts when fertilized ova (both adult male and female worms are necessary) are passed in the faeces. They then require a period of environmental development for which damp soil is ideal. When the resulting infective eggs are ingested via hands, food, dirt, utensils etc., larvae hatch and after migration via the lungs ascend the trachea and are swallowed and eventually reach the small intestine where after a few months development they live as adults for 1-2 years. As long as male and female adult worms are present, fertilized ova will be produced throughout this period. Excreted ova that do not immediately find a favourable environment for development can retard their development but remain viable for years until more suitable conditions are encountered. Ascaris ova are probably the most resistant to environmental conditions of all pathogens.

Transmission is most likely to occur within the family or families sharing a house plot. A major risk is thought to be uncontrolled defaecation by infants around the house plot or yard. Contaminated soil can then infect other children and adults.

<u>Ascaris</u> ova can pass intact through the digestive tract of domestic animals and chickens and may thus be more widely disseminated in their excreta.

The reported distribution of Ascariasis is characterised by <u>very</u> high rates around Mt. Kenya/Nyeri and also at Lamu. Other important areas are Meru and Isiolo. Best estimates for the relative frequency of positive laboratory findings from Annual Laboratory Returns (over the period 1958-1973) are given on the preceding page for the project site towns.

As with other faecal-oral infections, but perhaps more so with Ascariasis, control depends not only on the provision of sanitary excreta disposal facilities but on their effective use. It has been suggested that poorly used latrines may even increase transmission by concentrating the source of infection.

As has been mentioned, young children are probably the main source of transmission through depositing excreta indiscriminately around the house plot. Although, therefore, the provision of sanitary latrines is a major intervention as far as housing is concerned, Ascariasis is a good example of where this must be accompanied by behaviour modification through family education if positive results are to be achieved.

Household water supply for washing of hands, utensils etc. will assist the interruption of transmission but only if used correctly. If abused, water supply may simply add to waste-water disposal problems and may create even better soil conditions for Ascariasis ova.

NAIROBI	32%
THIKA	46%
NAKURU	19%
MACHAKOS	10%
ISIOLO	20%
MERU	22%
MOMBASA	46%
LAMU	24%
KAKAMEGA	18%
WEBUYE	28%
KISUMU	26%
KAJIADO	15%

Best estimates of positive Ancylostomiasis findings from Annual Laboratory Returns 1958-1973.

ANCYLOSTOMIASIS

- hookworm

Ancylostomiasis is an infection with one of the two species of human hookworm *Necator americanus* or *Ancylostoma duodenale*.

Whilst infection can be virtually symptomless, in endemic areas it is an important disease because of its frequent cause of anaemia. The most severe effects are usually experienced by older children and by young and middle-aged adults especially iron-deficiency prone groups like pregnant and lactating women. Where infection is intense, however, younger groups can be affected to the degree of mild or severe physical or mental retardation.

Transmission occurs when eggs produced by the adult female worm are passed in faeces. If these eggs are deposited in a suitable external environment they develop into larvae in a matter of 24 hours or more. After two further subsequent larval transformations taking about 6 days, the larvae are able to penetrate the human skin usually between the toes on feet or ankles. *Ancylostoma duodenale* can also be ingested.

A suitable external environment for survival of eggs includes soil of a light structure and with sufficient organic material, sufficient moisture (but not excessive since both dry and very wet conditions are fatal to the larvae after hatching), a temperature range of 28-32^{o}C (*Necator americanus*) or 20-27^{o}C (*Ancylostoma duodenale*). Wider ranges are tolerated but development is retarded and completely stopped outside the range 10^{o}C and 40^{o}C.

Once mature adult worms are established in the small intestine, the infection can be transmitted for up to a period of years.

Ancylostomiasis is widespread in Kenya. Parasitological investigations indicate the usual presence of *Necator americanus* but *Ancylostoma duodenale* is found in the coast region. Hookworm infection is highest in this region and around Lake

Victoria. The relative frequencies of positive findings from Annual Laboratory Returns are shown for each project town on the preceeding page.

Whilst the most obvious housing-related intervention must be that of sanitary faeces disposal, there is a great deal of evidence in fact on the ineffectiveness of this measure in areas of high prevalence. As with ascariasis, it seems that only when combined with changed behaviour on the part of the populations at risk will sanitation become effective. Poorly designed, used or maintained latrines will only serve to concentrate transmission risks. Infants and young children who continue to defaecate around the house yard will continue to infect others. Of course, an efficient intervention would be the constant wearing of shoes but this is a futile suggestion in poor communities. Chemotherapy is very effective but is short-lived if those treated must return to high risks of further infection.

Despite the above comments, however, exreta disposal must be considered a necessary if, by itself, insufficient component of hookworm control. Design is likely to be an important factor in housing development. Latrine floors must be surfaced with washable material and raised significantly above surrounding earth yards. Floors should have adequate slope towards the squatting slab so that they can be easily washed and are rapidly self-draining. They should be designed to avoid the spillage of water used for washing down onto surrounding earth - a step under the door for example. Plumbing arrangements should facilitate the washing of latrine floors and surrounds without the inconvenience of having to carry water very far to do this.

Above all, since all of the above will be useless without user understanding, there must be user education.

Urban housing and upgrading programmes provide at least the basis for control. Chemotherapy campaigns are very effective and can follow the development of health services coverage but they will not succeed without improved sanitation and its safe utilization.

ENTEROBIASIS

Enterobiasis (threadworm or pinworm) is a worm infection of the large intestine which usually has only mild symptoms.

Transmission occurs when eggs are deposited by the female worm. These eggs are not normally passed in the faeces but are attached to the skin in the anal area. These can be transmitted to the mouth by contaminated fingers or soiled clothes and bed linen. Self-infection also occurs when hatched eggs from the anal area re-enter the bowel to mature into adult worms.

Enterobiasis is most common in children. The principle intervention is the provision and use of household water for hand and body cleanliness.

It is certainly widespread in Kenya wherever overcrowding occurs and where personal cleanliness is deficient.

	(S.haematobium)	(S.mansoni)	
NAIROBI	Very little	Very high in places	S.mansoni all along the Nairobi River. 80% positive in children 3-9 years in Mathare; 28% Kibera.
THIKA	Yes	Yes	Mostly S.haemantobium.
NAKURU	No	No	Neglegible
MACHAKOS	Very little	Very high	Highest S.mansoni prevalence in Kenya.
ISIOLO	Little	No	
MERU	No	No	
MOMBASA	High	No	But probably peripheral to town.
LAMU	Yes	No	Probably not in the town.
KAKAMEGA	No	No	But snails are there.
WEBUYE	Some	Very little	
KISUMU	Yes	Yes	S.haematobium in the rivers; S.mansoni along the shoreline.
KAJIADO	Very little	Some	

SCHISTOSOMIASIS

Schistosomiasis is an infection by species of flatworm Schistoma. S. haematobium occupies the veins around the bladder whilst S. mansoni occupies those around the intestines. The main damage of this infection is caused to tissue when eggs escape into the bladder or bowel. The complication this causes and the severity vary greatly. Very serious illness and death can result but mostly, Schistosomiasis is a chronic illness. Even in light infections, however, it can result in retarded childhood growth and much reduced physical abilities.

The transmission cycle is maintained when eggs passed in urine or faeces come into contact with fresh water inhabited by one or other of two quite common species of snail - the intermediate host. The eggs hatch in the water producing a mobile larva (miracidium) which then searches for a suitable snail. It is thought to have a viable period of up to about 6 hours to do this. The larva penetrates the snail where it develops through a series of life-stages. Between 1-3 months later, another form of aquatic larva (cercariae) emerge from the snail. These survive up to 48 hours but if they encounter human skin in this time they rapidly penetrate the body. After further development involving migration via the lungs and liver, they mature as worms and male-female pairing occurs before they eventually move to the appropriate blood vessels.

Heavy infection occurs, therefore, wherever man is frequently in contact with infected water systems. The most favoured habitats for the snail hosts are still or slowly flowing waters including ponds and especially canals. Schistosomiasis tends therefore to be primarily a rural disease but can occur wherever man inbabits land close to suitable water and wherever contact with that water is frequent whether this be for drawing water, personal washing or the washing of clothes, fishing, childrens play etc. For the transmission cycle to continue, urine or faeces must be deposited sufficiently near the water to allow access by the Schistoma eggs.

New irrigation schemes constitute one of the major risks of spreading this infection to previously unexposed populations. Once infection is established, it becomes tremendously difficult and expensive to control.

Both forms of schistosomiasis are common in Kenya and it has been estimated that something like 1 million people are infected. In relation to the proposed project study areas the following distribution occurs:-

S. haematobium:

Very high prevalence along the coastal strip including Mombasa (but no S. mansoni here). Lower but still significantly high prevalence around Lamu and Kisumu. Other important foci exist around Machakos and Thika and possibly some around Kakamega and Webuye - certainly the snails exist there.

S. mansoni:

Very high prevalence around Machakos. Important prevalence around Thika and smaller foci around Kisumu. Heavy infestation of S. mansoni exists in pockets in and around Nairobi especially in Mathare, Kibera and virtually all along the Nairobi River.

As is the case with many excreta related diseases, control is in theory straightforward but in practice very difficult. For schistosomiasis the key points of intervention are the sanitary control of urine and excreta and the removal of water contact. It would seem then that wherever new housing development is implemented, the provision of sanitation would go a long way in reducing transmission. This intervention fails, however, wherever agricultural work patterns allow the passing of urine and excreta away from home or where children continue to use nearby water as play areas. The provision of household water supplies can also reduce the need for much contact with contaminated canals, streams or ponds. To be effective, new housing development must be accompanied by health education about schistosomiasis wherever that risk exists.

Wherever there is a choice, new housing developments should be sited well away from known foci of infection and access to the watercourse made as unnecessary as possible.

4. Maternal & Child Health and Nutrition

5. Accidents

6. General Acute & Chronic Disorders

(Work not yet complete)

7. HEALTH AND VITAL STATISTICS

The previous sections of this Appendix have reviewed the nature and what is known about the distribution of specific diseases in the country.

Here a very brief review is presented of how those diseases and ill-health conditions appear as statistics in terms of morbidity and mortality.

The classical yardsticks of life expectancy, birth experience and mortality rates depend to a great extent upon the collection of information in a systematic way. In Kenya statistics of this kind stem from the censuses of 1948, 1962, 1969 and eventually 1979 results. In addition there is an (incomplete) system of birth and death registration and limited surveys of specific diseases and other conditions going back many years.

Birth and death registration is currently compulsory in areas applying to 65% of Kenya's population but it is estimated that in these areas death registration applies only to 30-35% of deaths. There is no similar published information about the completeness of birth registration. However, it is likely that this is more complete than registration of deaths and completeness is likely to be high since a birth certificate is required for various purposes.

The expectancy of life reported in 1962 was 40 years for males and 45 years for females. This had risen by 1969 to 47 for females and 51 for males.

Life expectancy figures in 1969 showed considerable variation in different parts of the country, the worst experience being that of the North Eastern Province where the figures were 43.9 for males and 46.2 for females. On the other hand, the best figures were experienced in Nairobi where they were 59.9 for males and 63.8 for females with an average figure of 61.8. The average expectancy was high also at the Coast 55.7 and in the Central Province 54.6.

Caution needs to be exercised in making conclusions from these figures, however. Whilst Nairobi and the Central Province have topographical circumstances which would tend to reduce the prevalence of tropical disease, this is certainly not so with regard to the Coast Province. It might be that socio-economic factors are operating particularly at the Coast since it is nowadays practicable to live in a potential hazardous environment if there is sufficient will, knowledge and financial ability to overcome the conditions.

It would be dangerous on the basis of this information to conclude that living in Nairobi was the least hazardous from the health point of view. It is clear that Nairobi's population retains links with other areas and it might well be that the sick and the dying return to their homelands. Nairobi too is the area in Kenya with the greatest range of social classes. It may be that the relatively well-to-do cause a bias in the total figures. It has not been possible to determine quantitatively from past reports to what extent the health experience in the slum areas compares with those living in different housing zones of the city although in earlier sections the risk factors associated with main diseases have been mentioned.

The crude birth rate can only be determined reliably from calculations between census periods. Estimated figures for Kenya as a whole since 1950 are as follows:-

1950-54	48.6
1955-59	47.7
1960-64	47.0
1965-69	48.8

Clearly current trends depend upon the 1979 census returns.

These rates are high and are in line with an estimated population growth rate of 3.3-3.5% per annum. It is interesting that the birth rate for Nairobi in 1969 was reported as being 50 per 1000 population. Again, this latter figure needs careful interpretation. The registration of births particularly in Nairobi is likely to be high. Since this city has the best maternity facilities, it may be that mothers in fact move into the city for delivery and then move out again having registered birth.

The crude death rate figures are also still on the high side and these were reported since 1950 as follows:-

1950-54	18.3
1955-59	18.2
1960-64	18.3
1965-69	17.5

In 1969 the crude death rate reported for Nairobi was 8 per thousand population. Again, more information is required for these figures to be interpreted. If sick people, particularly small children, are removed from Nairobi when they are critically ill this would tend to reduce the figures. However, Nairobi offers more facilities for hospital and other treatment which would tend to counter this possibility. The pattern of deaths would clearly need considerable analysis before this striking difference in death experience compared with Kenya as a whole can be understood.

There is less information about the important measurement relating to infant mortality. There are no published figures relating to the censuses before 1969 so the trend is difficult to determine. In 1969 the figures were:-

For Males	126 deaths per thousand live births
For Females	112 deaths per thousand live births

Giving a total infant mortality rate of 119.

For the same year, the figure for Nairobi was 50 deaths per thousand live births. Since the infant mortality rate refers to deaths of children under one year it is important to know whether babies under this age remain in Nairobi after birth.

It would seem to be the case that if the life expectancy has risen as reported and the birth and death rates have changed very little since 1950, then there must have been considerable improvement overall in infant mortality. The 1979 Census report when it is available should confirm this.

Whilst, in general, current published information indicates an improvement in the health status of Kenya's population, it is not possible to indicate whether those living in the towns have a better or worse experience. There are indications that Nairobi's population by virtue of its topographical situation and its better facilities has a better health experience than those living elsewhere but it is not possible to determine whether this includes the poorer sections of the community. It is also not possible to determine from published information how people fare in other urban areas. In particular there is no way of determining from present information whether the slum dwellers of Nairobi or those unsuitably housed in other urban areas are suffering ill effects in health terms. It becomes necessary, therefore, to consider the specific risks of people in those areas to see what steps must be taken to minimise them.

Morbidity

Apart from data relating to notifiable diseases contained in the Statistical Digest for 1978, it is necessary to rely upon the Annual Report for 1968 and material analysed from it. It is probable that the pattern of disease has changed little since that data although it appears likely that the number of deaths of children under one year and probably under 5 years have been reduced. There have been no major eradications of disease (except for smallpox), although there has been a marked increase in the study of endemic diseases and the introduction of preventive measures against them and especially the communicable diseases of childhood.

Government hospital outpatient attendances for 1968 provided the following expected ranking for important diseases:-

767,892 Respiratory Disease

295,487	All forms of gastro-enteritis and intestinal parasites
255,525	Skin Disorders
202,434	Malaria
67,473	Venereal Disease
40,647	Measles
39,830	Kwashiorkor (malnutrition)
21,537	Whooping Cough
10,131	Tuberculosis
7,749	Schistosomiasis

It will be noted that the first few diseases account for the majority of attendances. Respiratory disease, as is so often the case, ranks first and is responsible for as many attendances as the next three diseases put together. Malaria is the commonest specific condition causing attendance but these are almost certainly clinical rather than parasitologically confirmed diagnoses and therefore probably an overestimate.

For admissions to hospitals, the ranking of diseases was as follows:-

1.	Pneumonia	10%
2.	Malaria	8%
3.	Gastro-enteritis & Colic	5%
4.	Measles	3.7%
5.	Wounds	3%
6.	Tuberculosis	2.9%
7.	Fractures	2.0%
8.	Whooping Cough	1.7%
	Other Causes	48%
	Childbirth	31%

The high ranking of malaria might be explained by seasonal or epidemic malaria occuring and causing more serious disturbance than usual within highly endemic areas.

Mortality

Leading causes of death reported in hospitals (not from death registration) are ranked as follows:-

1.	Pneumonia	26%
2.	Gastro-enteritis etc.	11%
3.	Malaria	5%
4.	Tuberculosis	5%
5.	Kwashiorkor	5%
6.	Measles	4.3%
7.	Tetanus	3.7%
8.	Whooping Cough	2.3%
	Other Causes	38%

Two major notifiable diseases have occured since 1968. From 1971 to 1973, Cholera entered Kenya first from the Ethiopia and Somalia in the North East and then from the Sudan and to a lesser extent from Uganda in the North West. These were thought to be the first introductions of Cholera in this century. Subsequently, in about 1974, Cholera was introduced into Nyanza Province in the South West. These epidemics were contained and controlled in a comparatively short time.

In 1977-78, a cholera outbreak occured in Mombasa where it proved more difficult to contain in some of the urban slum areas. Cholera could well emerge again in the future.

The second disease which has occured in epidemic proportions is plague. This disease can be regarded as endemic in Kenya though until recently there had been no epidemic since 1963. In 1978, a limited epidemic occured in the Masai areas but did not affect any major township or urban area. This disease remains a threat however, since many urban areas sustain large rat populations.

APPENDIX II

HOUSING TECHNOLOGIES FOR HEALTH

1. Health Aspects & Excreta Disposal Systems

2. Wastewater Disposal & Surface Drainage

3. Water Supplies

4. Ventilation and Climatic Comfort

5. 'Barefoot' Maintenance Technologies

APPENDIX II

HOUSING TECHNOLOGIES FOR HEALTH

1. Health Aspects of Excreta-Disposal Systems

A wide range of different systems exist for effecting the collection, removal and treatment of excreta. It is not the purpose of this Discussion Paper to deal exaustively with all of these nor is it the intention to cover the detailed design and specific engineering features of these alternative types. Some of this will be done in other Discussion Papers in this Study.

In this paper we shall only deal in principle with some of the major variations available and shall comment on each from a health perspective. We shall draw attention to some of the major advantages and drawbacks of these to form the basis for discussion.

One fact that should be constantly kept in mind in this Appendix is that although we refer to a number of distinct variations in sanitation systems, a large range of alternative detailed designs is possible within any one sanitation type. The Appendix thus only illustrates these major types.

Sanitation planning is essentially a problem-solving design exercise not selection from a shopping list of stereotypes. Sanitation engineering is too full of 'rules of thumb' and conventions that are nowadays largely obsolete. Rather than simply applying such rules, the engineer has to ask 'what did they aim to achieve?' 'what are the design constraints for this particular problem solving task' etc.

Later in this Study, we shall undertake a detailed reletive costing exercise for a small number of alternative sanitation designs selected for their possible suitability for Kenya. We shall take a typical low-cost site layout and a typical standard house design and will show the costs of servicing this with different systems, discussing the pros and cons of each.

The following details are largely taken directly from available publications on this subject, most notably "Appropriate Sanitation Alternatives: A field manual" by D. Mara, J. Kalbermatten et al, World Bank, 1978 from which large sections are reproduced.

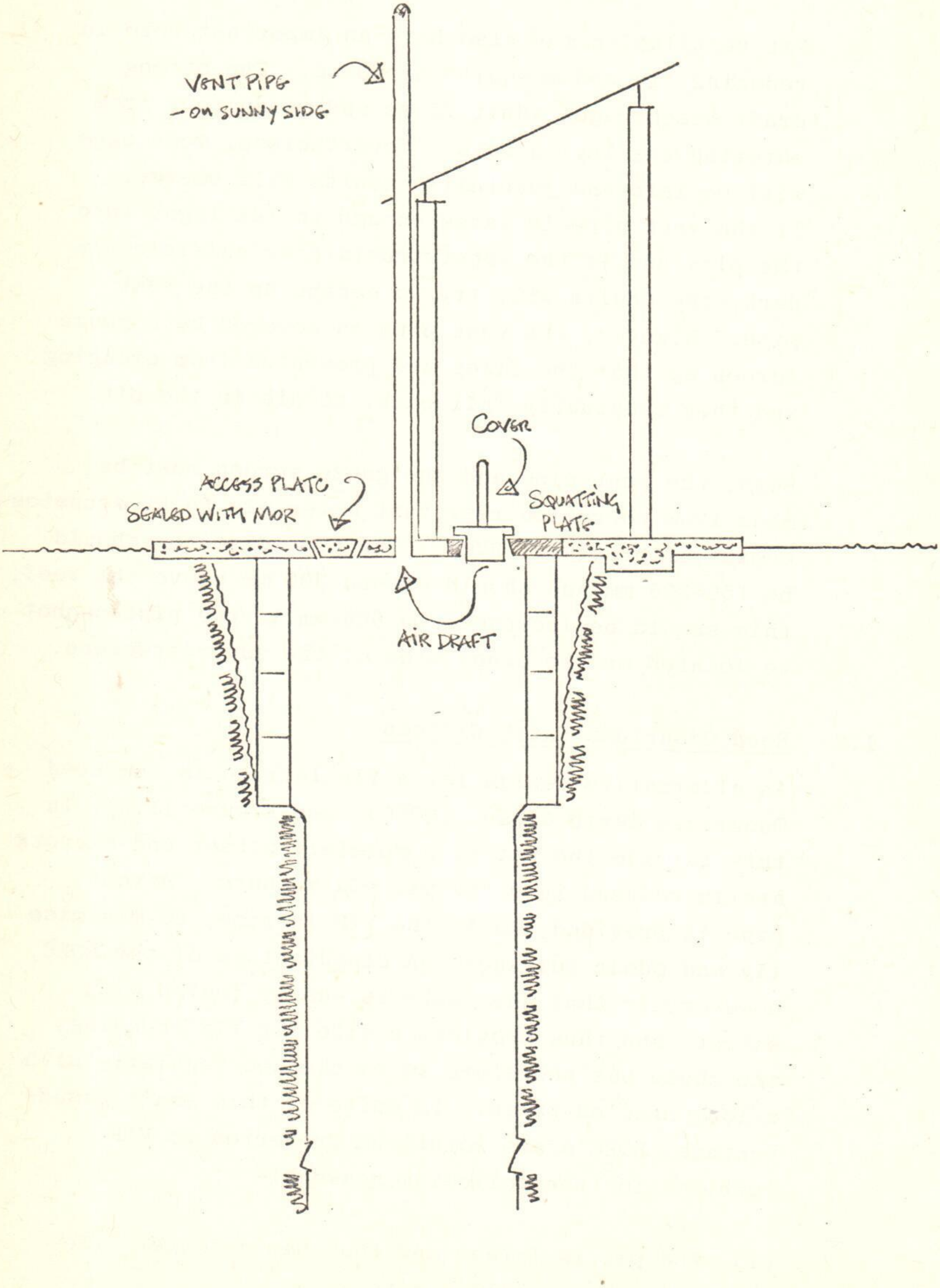
1.1 The Improved Pit Latrine

The simple pit latrine has two major disadvantages: it usually smells, and flies or mosquitoes readily breed in it, particularly when it is filled to within one meter of the surface. These undesirable attributes have led to the rejection of the pit latrine in favor of other, far more expensive forms of sanitation, but they are almost completely absent in ventilated improved pit latrines and Reed Odourless Earth Closets. It is therefore recommended that unimproved pit latrines should no longer be built, and that those that do exist should be converted.

Recent work has provided designs for pit latrines (see Figure II,1 for example), that are odorless and have minimal fly and mosquito nuisance. Ventilated improved pit (VIP) latrines are a hygienic, low-cost and indeed sophisticated form of sanitation, which has only minimal requirements for user care and municipal involvement. The pit is slightly offset to make room for an external vent pipe. The vent pipe should be at least 150 mm in diameter (preferably 200 mm); it should be painted black and located on the sunny side of the latrine superstructure. The air inside the vent pipe will thus heat up and so create a vigorous updraft with a corresponding downdraft through the squatting plate.

FIGURE II, 1

VENTILATED IMPROVED PIT LATRINE - BASIC PRINCIPLES



Thus any odour emanating from the pit contents are exhausted via the vent pipe, leaving the superstructure odour free.

Pit ventilation may also have an important role in reducing fly and mosquito breeding. The strong draft discourages adult flies and mosquitoes from entering and laying eggs. Nevertheless, some eggs will be laid and eventually adults will emerge. If the vent pipe is large enough to let light into the pit, and if the superstructure is sufficiently dark, the adults will try to escape up the vent pipe. However, the vent pipe is covered by a gauze screen so that the flies are prevented from escaping and they eventually fall back, to die in the pit.

Both, the vent pipe and the gauze screen must be made from corrosion resistant materials (e.g. asbestos cement, fibreglass, PVC). The pipe diameter should be 150-200 mm and should extend 300 mm above the roof; this should be increased to 600 mm if the pipe cannot be located on the sunny side of the superstructure.

1.2 Reed Odourless Earth Closets

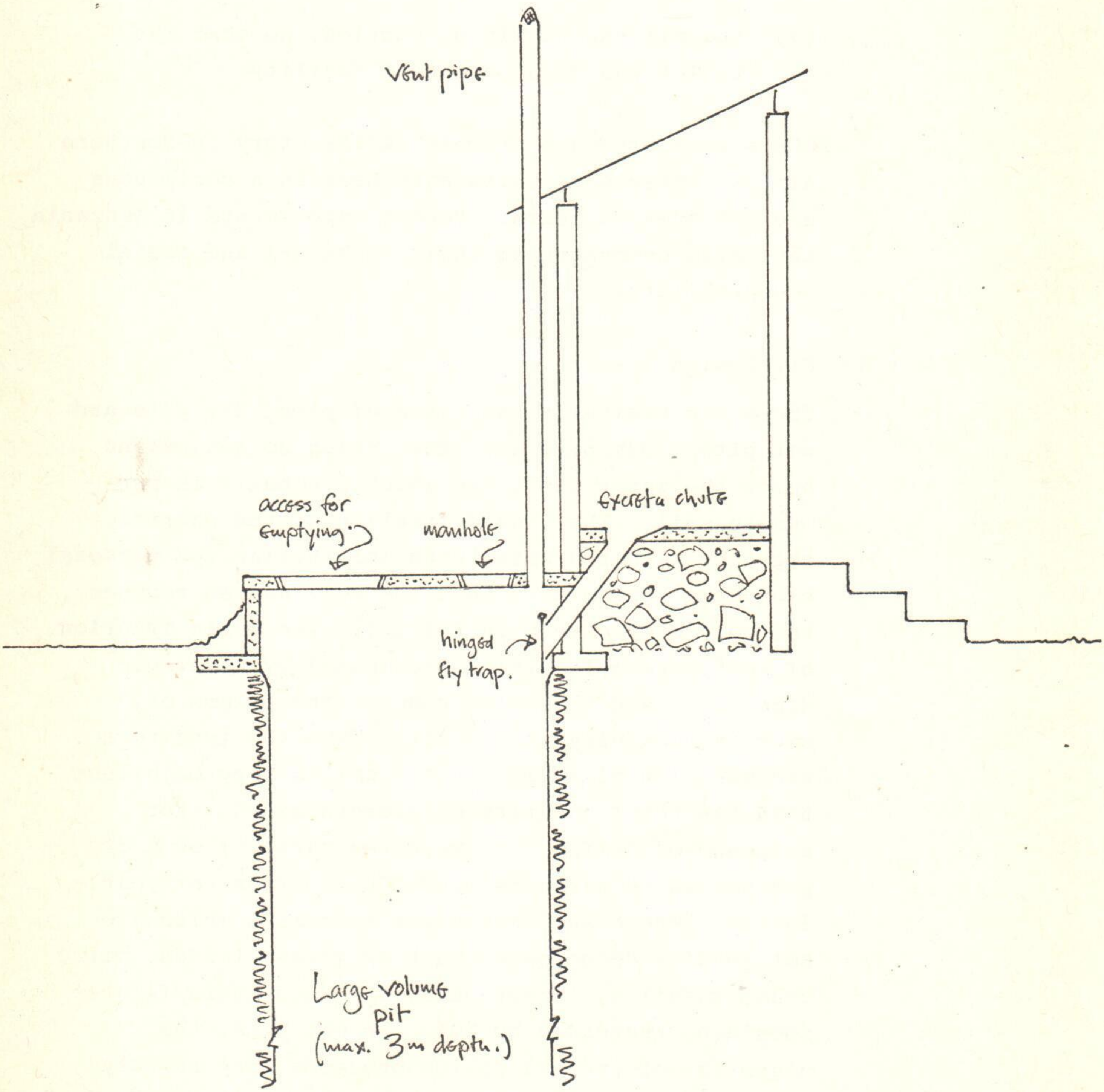
An alternative design for a VIP latrine is the Reed Odourless Earth Closet (ROEC) (see Figure II,2). In this latrine the pit is completely offset and excreta are introduced into the pit via a chute. A vent pipe is provided, as in the VIP latrine, to minimise fly and odour nuisance. A disadvantage of the ROEC, however, is that the chute is easily fouled with excreta and thus provides a site for fly breeding; the chute has therefore to be cleaned regularly with a long handled brush. In spite of this small disadvantage, ROEC's are sometimes preferred to VIP latrines for the following reasons:-

(1) the pit is larger and thus has a longer life than other shallow pits;

Figure II, 2.

REED ODOURLESS EARTH CLOSET

– BASIC PRINCIPLES.



(2) as the pit is completely displaced, the users (particularly children) have no fear of falling into the pit;

(3) it is not possible to see the excreta in the pit; and

(4) the pit can easily be emptied, so that the toilet can be a permanent facility.

ROECs have proved extremely satisfactory in Southern Africa, where some units have been in a continuous use for over 20 years. Recent experiments in Tanzania have also demonstrated their technical and social acceptability.

1.3 Pit Design

There are basically two types of pits: dry pits and wet pits. Dry pits are those which do not extend below the water table and which are built in permeable soil. The liquid fraction of the excreta, together with the water used for latrine and personal cleansing, percolates into the soil and so reduces the volume of exreta in the pit. The solid fraction of the excreta is slowly decomposed by anaerobic digestion, and this also reduces the volume of excreta remaining in the pit. Thus the long-term accumulation of solids in the pit is very much less than the total quantity of excreta added. For purposes of design, the required capacity of a dry pit should be taken as 0.06 m^3 per person per year. In areas where anal cleansing materials which are not readily decomposed (such as grass, leaves, maize cobs, mudballs, cement bags) are used, this figure should be increased by 50%. In wet pits, the digestion of excreta solids proceeds more rapidly than in dry pits. A design capacity of 0.04 m^3 per person per year should be allowed; again, this should be increased by 50% if resistant anal cleansing materials are used.

Pit latrines should be designed for a minimum life of 5 years and preferably for as long as 10 or even 15 years. The temptation to built small pits should be resisted wherever possible, as it substantially increases the annual cost.

Traditionally, new pits are dug when old ones are almost full. The latter are then filled in and, providing they are left for a year or so, become completely pathogen free. In higher density areas, however, there is rarely space to construct subsequent pits and they have to be emptied. Providing this is done by vacuum truck there is no health risk. VIP latrines as well as REOC's should, where this will be the case, be constructed to allow such desludging.

Pit depths are usually in the range 3-8 m although pits of 12 m or more are found where soils are particularly suitable. With VIP latrines it is sometimes advantageous to use very much enlarged pits provided that the ground conditions are suitable.

The upper part of the pit should be lined so that it can properly support the squatting plate and superstructure. If this is not done, the pit may collapse. In unstable soil conditions it may be necessary to extend this lining down to the bottom of the pit but care must be taken to ensure that the lining does not prevent infiltration.

In areas where the water table is within 1 m of the ground surface, or where excavation is difficult (as, for example, in rocky ground), a built-up pit can be used. The raised plinth should not be more than 1 m above ground level and the watertight lining should extend at least 0.5 m, and preferably 1 m, below ground level.

Brief discussion

Like all excreta disposal systems, VIP latrines and ROECs require maintenance. However, this maintenance is of a very simple kind and consists principally of keeping the squatting plate and superstructure clean. To prevent mosquito breeding in wet pits, a cupful of kerosene should be added to the pit each week.

In many parts of the world pit latrines have become grossly fouled and often constitute a greater health hazard than promiscuous defacation in the garden or alleys. This is not because of any inherent tendency of pit latrines to become fouled, but because they have often been introduced without sufficient user participation or education into communities which had never previously had any sanitation facility whatsoever. In such communities, other types of latrines would doubtless be equally fouled.

VIP latrines and ROECs are especially suitable in low and medium density areas (up to approximately 300 people per ha or even higher). In such areas houses are normally single-storied and there is sufficient space on each plot for at least two pit sites (one being in use and the other in reserve). However, they can be used at much higher densities (500-600 people per ha) if the pit volume is increased or pits and vaults are easily accessible for emptying and if sullage water disposal is properly managed. Both types of latrine are easy to construct (except in sandy or rocky ground, or when the water table is high), and usually much, if not at all, of the construction can be done by the users. The construction materials are standard and none generally has to be imported.

Pit latrines contaminate the soil and groundwater and this is obviously dangerous if shallow wells are located nearby (within 10 m or so). If the soil is fissured, the pollution is more extensive and is particularly serious if it affects borehole supplies for large populations.

Pit latrines should obviously not receive household waste-water and therefore, separate arrangements must be made for this. Soakways are satisfactory if constructed well in the first place - preferably with a simple grease trap - and their life can be extended indefinitely with appropriate tree planting to take up the surplus water.

Health Aspects

Provided the squatting place is kept clean, a VIP latrine or ROEC poses a health risk to the user scarcely greater than does a flush toilet. The only area of slightly increased risk is the small hazard of the occurrence of fly and mosquito breeding. However, this is most unlikely to result in serious nuisance if the vent pipe is of the correct size, properly located on the sunny side of the latrine and painted black.

Although both the VIP latrine and the ROEC are designed to minimise mosquito breeding, additional precautions can be taken in wet pits. Trials in West Africa have shown great success by covering the liquid surface with a layer of small polystyrene pellets (as used in soft furnishings). These bar access by mosquitoes to the liquid surface and will rise and fall with the surface level. These trials indicate that even though in the dry season the pellets become attached to the solids level, they float again when the subsequent rain season fills the pit.

Otherwise, Dursban or a similar larvaecide can be added where Culex fatigans is a serious problem but this is expensive in the long run. As noted earlier, a cupful of kerosene will do instead.

In lower density areas where space is available to dig new pits, the old pit contents can be safely dug out after they have been sealed in the ground at least 12 months. At most, there will be only a few viable Ascaris ova remaining after this time. If, as is recommended earlier, the pit has a minimum life of 5 years then its contents will not be dug out before at least another 5 years have elapsed (the second pit having been in use for the second 5 year period), and after this time the pit contents will not contain any viable excreted pathogens whatsoever.

In higher density areas where pits have to be emptied, the infrequency with which this has to be done with a well designed pit achieves tremendous savings.

Main advantages:-

- extremely low annual costs
- low construction costs and ease of construction (unskilled labour with site supervision)
- ease of maintenance
- minimal odour
- minimal fly or mosquito problem if well designed and constructed
- water only required for cleaning squatting plate (and chute for ROEC)
- very low management requirements by authorities (very occassional emptying)
- minimal risks to health

Main disadvantages:-

- unsuitable (anyway not ideal) for high density areas.
- unsuitable for areas where groundwater is obtained in shallow wells
- unsuitable in fissured soil as pollution can then be quite extensive and may affect other water supplies
- pits cannot be dug to the required depth in rocky ground
- black cotton soil has low soakage potential
- separate arrangements are required for waste-water disposal.

1.4 Pour-Flush Toilets

In its simplest form the pour-flush toilet (PF) is essentially a modification of the pit latrine in which the squatting plate is replaced with a simple bowl with a water seal. Approximately 1-2 litres of water (or sullage) are poured in by hand to flush the excreta into the pit. This type of PF toilet is often used with wet pits as the water seal prevents odour development and mosquito breeding. It is especially suitable where water is used for anal cleansing.

A second type of PF toilet, which is widely used in India, south-east Asia and some parts of Latin America, is used in combination with a completely offset pit. The PF bowl is connected to a short length (8 m maximum) of 100 mm diameter pipe which discharges into an adjacent pit. Approximately 1-2 litres of water are required for each flush. The slope of the connecting pipe should be not less than 1 in 40. The pit is provided with a concrete or ferrocement cover slab and wall lining as necessary. This type of PF toilet may be installed inside the house, as it is free from both odours and fly and mosquito nuisance; it therefore obviates the need for a separate external superstructure, and it can thus meet social aspirations for an "inside" toilet at low cost. When the pit is full, it can be emptied or, alternatively a new pit can be dug and the toilet connected to it.

Assuming that flushing only takes place when stools are passed and that a maximum of 3 stools are passed per person per day, the maximum water requirement is 6 lcd.

Health Aspects

If properly used and maintained, PF toilets are as safe as any. They also are free of mosquito and fly breeding without additional maintenance measures.

Advantages:-

- water seal maintains the system odour free
- no fly and mosquito breeding
- large self-help component in construction
- low capital costs (though more than those for VIPs or ROECs)
- low annual costs
- low management requirements by authorities
- minimal health risks if used properly

Disadvantages:-

- additional wastewater disposal required
- householder must ensure sufficient supply of flushing water in the toilet at all times
- all the disadvantages of groundwater pollution risks associated with VIP latrines and ROECs and, therefore, not suitable for high densities except in ideal ground conditions

- requires periodic emptying (by vacuum truck) although as with VIPs and ROECs, this could be as infrequently as every few years
- not ideal where large anal cleansing materials are used as blockages will occur in the water seal and/or sufficient water may not be available/used to ensure adequate flushing
- similar disadvantages to VIPs and ROECs regarding the soakage capacity of black cotton soil.

Sewered pour-flush

A third type of pour-flush system replaces the soakage pit with a septic tank with an outflow to a small-bore sewer (see Figure II,3). The sewered PF system is suitable for use in areas where the wastewater flow exceeds soakaway capacity. It can either be developed from an existing PF pit latrine or can be installed as a new facility.

The sewered PF toilet system has 5 parts:-

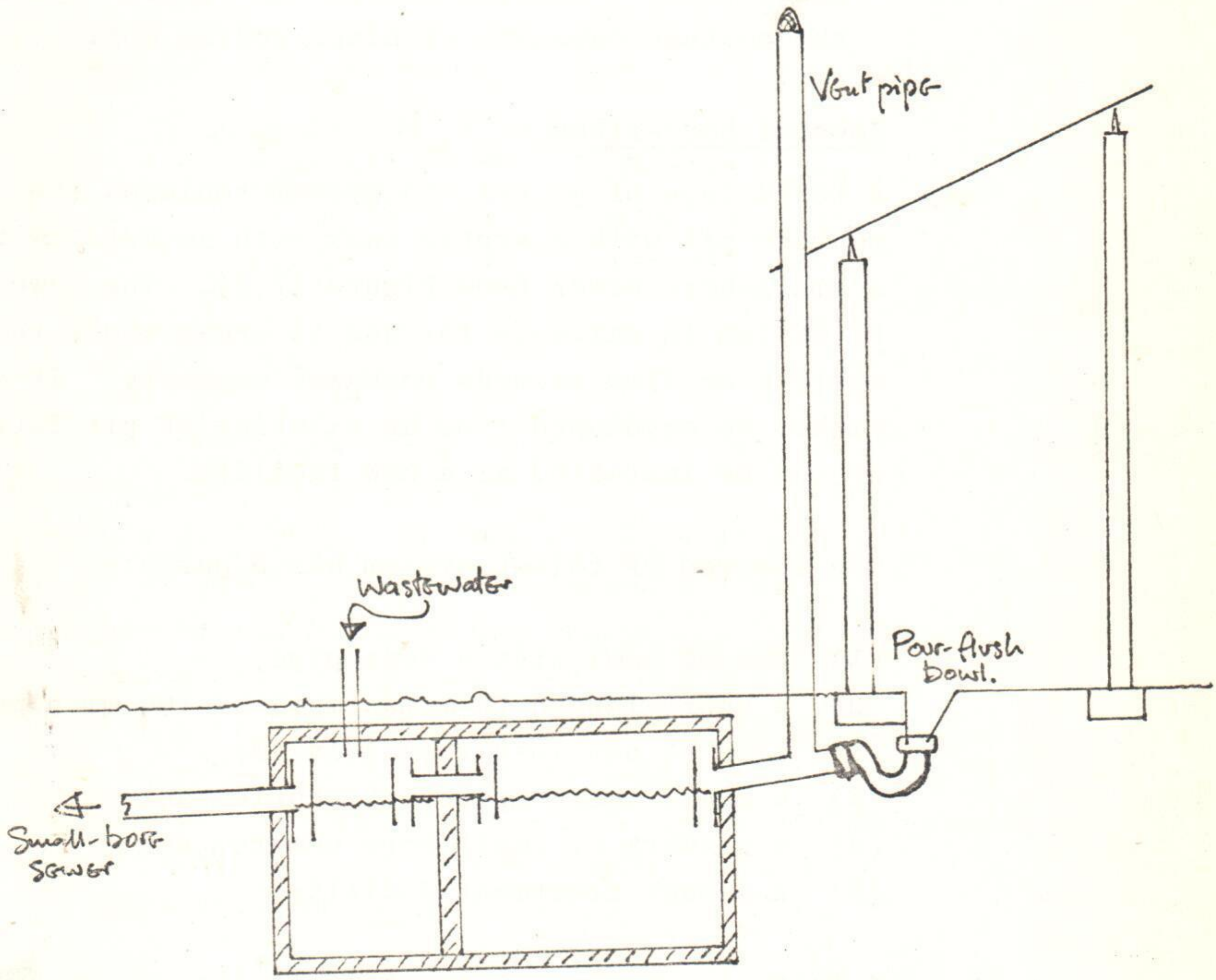
(1) the PF bowl, with a vent pipe;
(2) a short length (8 m maximum) of 100 mm pipe laid at not less than 1 in 40;
(3) a small two-compartment septic tank;
(4) a network of small bore sewers; and
(5) a sewage treatment facility.

A typical arrangement is shown in the accompanying diagram. Excreta and PF water only are discharged into the first compartment of the septic tank, and sullage only into the second. The two compartments are interconnected by a double T-junction, the invert of which is a nominal 3 cm above the invert of the exit pipe of the second compartment which is connected to the street sewer. Thus the contents of the first compartment are able to overflow into the second but sullage cannot enter the first compartment.

FIGURE II,3

SEWERED POUR-FLUSH

- BASIC PRINCIPLES



This arrangement effectively eliminates the very high degree of hydraulic disturbance caused by high sullage flows which, in single compartment tanks, would resuspend and prematurely flush out some of the settled excreta; it thus permits a considerably higher retention time of excreta in the tank and hence is able to achieve a substantially increased destruction of excreted pathogens.

Guidelines for the size of the two-compartment septic tank may be developed as follows. Assuming a per capita daily production of excreta of 1.5 litres and a maximum pour-flush water usage of 6 litres, the maximum toilet wastewater flow amounts to 7.5 lcd. Allowing a mean hydraulic retention time of 20 days in the first compartment implies a volume requirement of 0.15 m^3 per user. Thus the volume of the first compartment should be calculated on this basis of 0.15 m^3 per user, subject to a minimum volume of 1 m^3. The nominal hydraulic retention time in the second, or sullage, compartment, need be only 12 hours, subject to a minimum volume requirement of 0.5 m^3. For design purposes the sullage flow may be estimated as the water consumption (that is, the relatively small volumes of PF water may be ignored). The minimum recommended size tank (1.5 m^3 working volume) is thus suitable for up to 7 users and a water consumption of 140 lcd.

Since all but the smallest solids are retained in the septic tank, it is not necessary to ensure self-cleansing velocities of 1 m/s in the receiving sewers. As a result small bore sewers of 100-150 mm diameter can be used and these can be laid at flat gradients of 1 in 150-300. Sullage water carries no solids which could clog sewer pipes. Consequently, manholes need only be provided at pipe junctions. Thus the sewered PF system achieves considerable economies in pipe and excavation cost as compared with a conventional sewerage system. Taking into account these savings, the extra cost of the small septic tank, the savings in water usage and the lower cost of the toilet fixtures, the annual economic cost of a sewered PF system can be expected to be considerably (of the order of 50-70%) less expensive than that of cistern-flush toilets connected to a conventional sewerage system. In addition, treatment costs will be less, due to the enhanced pathogen removal and BOD reduction (approximately 30-50%) in the septic tank.

Advantages:-

- all the advantages of the simpler PF systems discussed above
- can be used in soils with low soakage capacity
- no groundwater pollution risk
- small size of septic tank means that it will be possible to construct in almost any soil/rock conditions
- low maintenance costs (but introduces a sewage treatment cost)
- no additional wastewater disposal provision required
- emptying requirements will be even more infrequent as decomposed solids will enter sewer with liquids

Disadvantages:-

- higher construction costs than any system considered so far
- requires a sewage treatment facility (but this could be a site waste stabilisation pond rather than a municipal sewage works)
- household must provide sufficient flushing water on a regular basis
- not ideal where large anal cleansing materials are used (as for other PF systems above).

1.5 Aqua-Privies

There are three essential variants of the aqua-privy:-

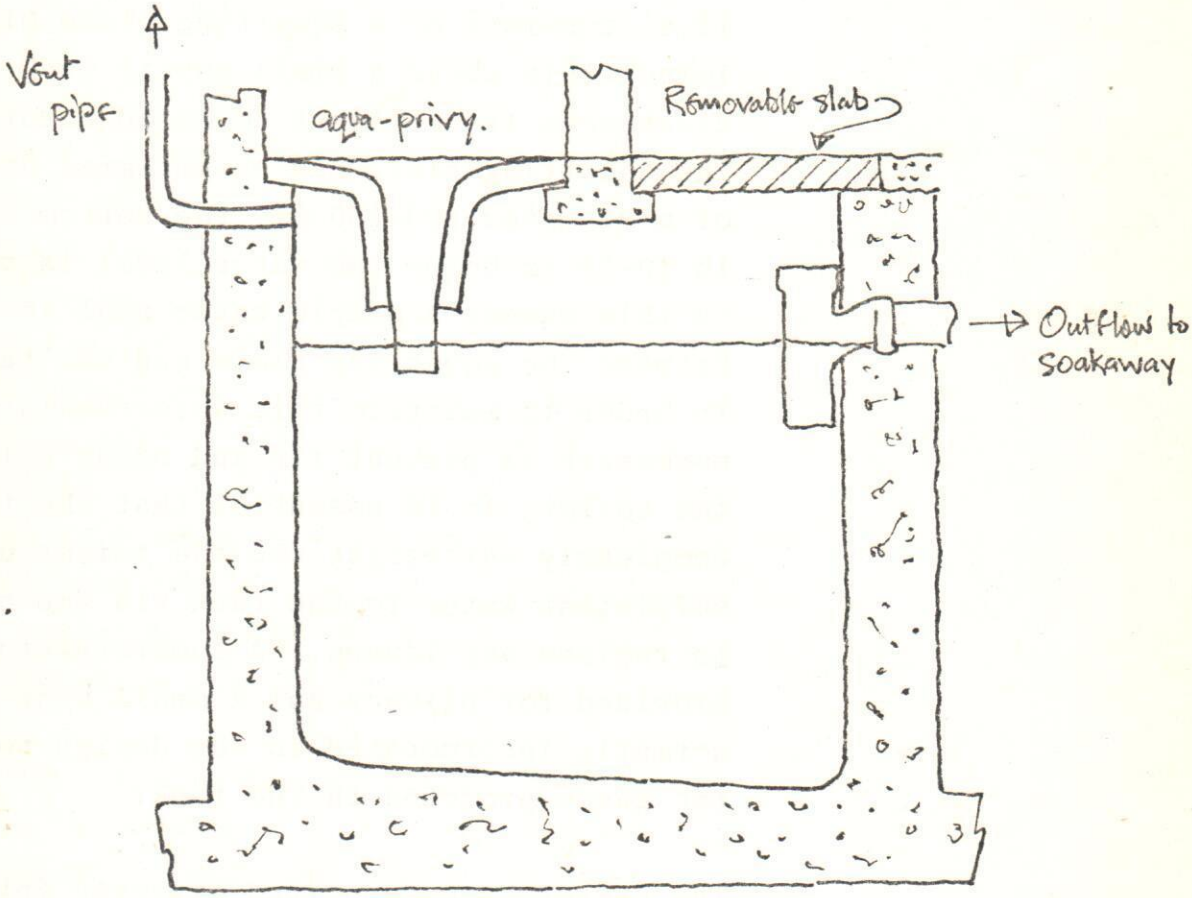
i) the conventional type
ii) the self-topping type
iii) the sewered type

i) The conventional aqua-privy toilet (see Figure II,4) consists of a squatting plate situated immediately above a small septic tank which discharges its effluent to an adjacent soakaway. The squatting plate has an integral drop-pipe, of a diameter 100-150 mm, the bottom of which is 10-15 cm below the water level in the tank. In this manner a simple water seal is formed between the squatting plate and the tank contents. In order to maintain this water seal, which is necessary to prevent fly and odour nuisance in the toilet, it is essential that the tank be completely watertight and the toilet user add sufficient water to the tank via the drop pipe to replace any losses. A superstructure is provided for privacy and a small vent pipe is normally incorporated in the design to exhaust the gases produced in the tank.

The excreta are deposited directly into the tank where they are decomposed anaerobically in the same manner as in a septic tank. There is, as with septic tanks, a gradual accumulation of sludge (approximately 0.03-0.04 m^3 per user per year) which should be removed when the tank is two thirds full of sludge. The tank volume is usually calculated on the basis of 0.12 m^3 per user, with a minimum size of 1 m^3. Disludging is normally required every 2-3 years when the tank is two-thirds full of sludge. The liquid depth in the tank is normally 1-1.5 m in household units; depths of up to 2 m have been used in large communal aqua-privies.

FIGURE II, 4

CONVENTIONAL AQUA-PRIVY.



The volume of excreta added to the aqua-privy tank is approximately 1.5 lcd, and the water used for 'flushing' and maintenance of the water seal is about 4.5 lcd; thus the aqua-privy effluent flow is around 6 lcd. The soakaway should therefore be designed on this basis, although it is common to include a factor of safety so that the design flow would be, say, 8 lcd. The sidewall area of the soak-away should be calculated assuming an infiltration rate of 10 litres/m^2 day.

Maintenance of the water seal has always been a problem with conventional aqua-privies, except in some Islamic communities where the water used for anal cleansing is normally sufficient to maintain the seal. Even there, however, it is necessary for the vault to remain water tight. In many other communities people are either unaware of the importance of maintaining the seal or they dislike to be seen carrying water into the toilet. If the seal is not regularly maintained, there is intense odour release and fly and mosquito nuisance.

ii) The self-topping, sullage or wastewater aqua-privy was developed to overcome the problem of maintenance of the water seal. In this simple modification of the conventional system all the household sullage is added to the tank; the water seal is thus readily maintained and the sullage is conveniently disposed of. Although the sullage can be added to the tank via the drop-pipe, it is more common, and for the user more convenient, for it to be added from either a sink inside or immediately outside the toilet or from one located in an adjacent sanitation block. Naturally, as the volume of water

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entering and leaving the aqua-privy tank is increased by the addition of sullage, the soakage pit capacity must be increased to absorb a larger flow. Sullage aqua-privies cannot, therefore, be used in urban areas where the soil is not suitable for soakaways or where the housing density or water usage is too high to permit subsurface percolation for effluent disposal.

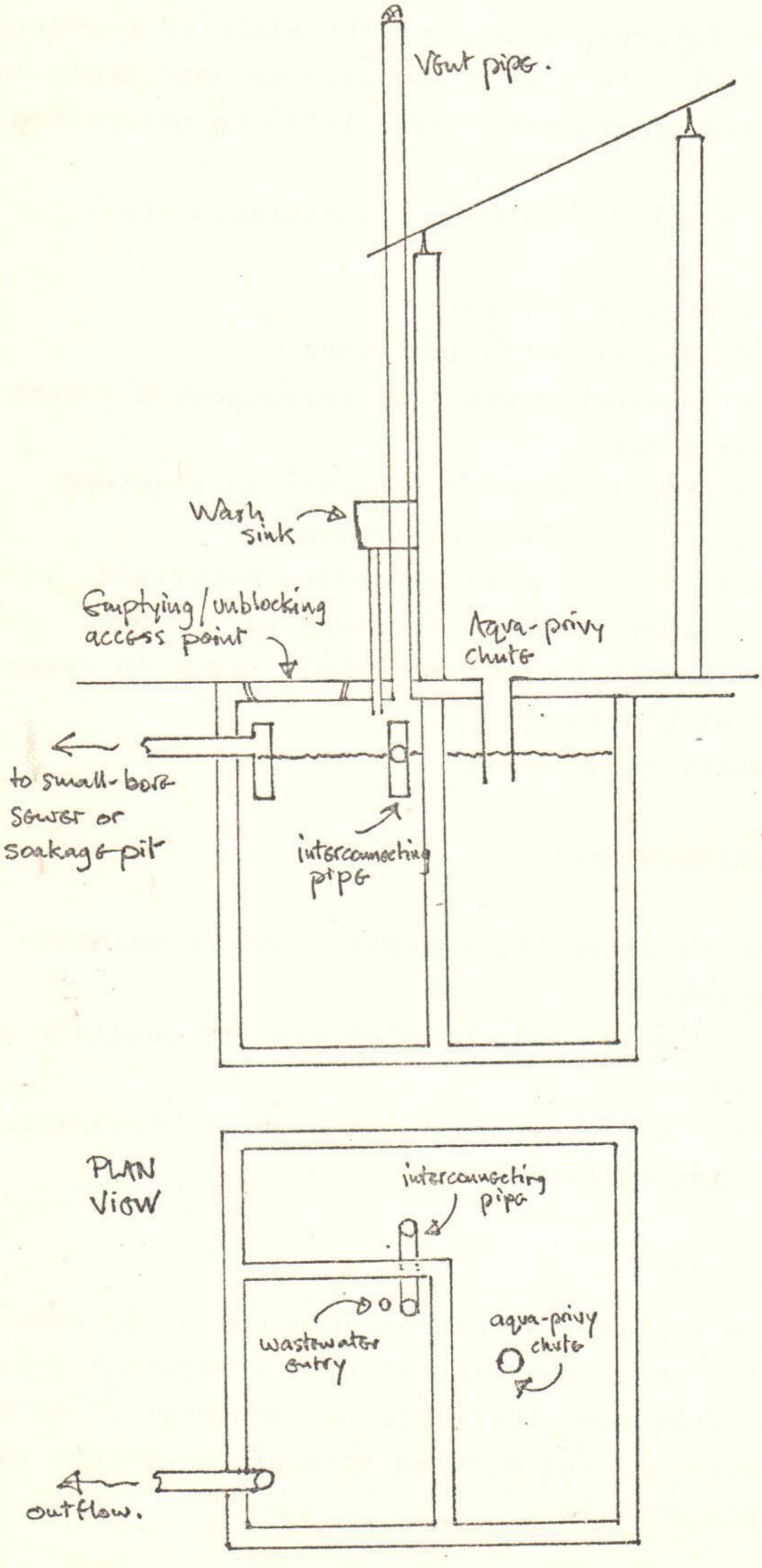
iii) The sewered aqua-privy replaces the soakage pit with a septic tank the outflow of which is connected to a small bore sewer system. Since all but the smallest solids are retained in the aqua-privy tank the sewers can be of small diameter and laid at the nominal falls necessary to ensure a velocity of around 0.3 m/s rather than the self-cleansing velocity of 1 m/s required in conventional sewers transporting raw sewage. Commonly 10-15 cm pipes are used at a fall of 1 in 150-300. Substantial economies in sewer and excavation costs are thus achieved, and sewered aqua-privy systems are therefore considerably (50-60%) less expensive than conventional sewerage systems.

This system is much improved by the modification of adding a separate wastewater receiving compartment (see Figure II,5). This is provided to avoid hydraulic disturbance of the settled excreta in the main part of the tank. The invert of the pipe connecting the two compartments is a nominal 30-50 mm below the invert of the effluent pipe from the sullage compartment (which leads to the soakage pit or sewer), so that the sullage flow can be used to maintain the water seal in the main compartment, but is unable to resuspend the settled excreta.

FIGURE II.5

AQUA-PRIVY.

- IMPROVED, TWO-TANK, SELF-TOPPING



Wastewater flows into 2ND compartment avoiding hydraulic disturbance in septic tank.

Interconnecting pipe ensures septic tank remains topped up to level above base of excreta chute.

Advantages and Disadvantages

The main disadvantages of the self-topping aqua-privy are those of all systems requiring soakage capacity in urban areas and the risks of pollution. In addition, the system requires an absolutely water-tight tank if the water seal is to be maintained.

For the sewered aqua-privy, advantages are:-

- can be used in any soil
- no groundwater pollution risks
- low maintenance costs (but introduces a sewage treatment cost)
- no additional wastewater provision required
- infrequent emptying requirements
- suitable for any anal cleansing materials
- much cheaper than conventional water-borne sewage for much the same result and with fewer risks of blockage
- low water requirement

Disadvantages are:-

- requires a water tight septic tank to maintain water seal
- more expensive than simpler systems considered earlier
- requires a sewage treatment capacity (stabilisation ponds are suitable).

1.6 Septic Tanks

The term septic tank can be applied to any tank in which the anaerobic digestion of sewage takes place. Septic tanks are, therefore, a component of both the sewered PF and sewered aqua-privy systems as described earlier.

Essentially, septic tanks are small, rectangular chambers, usually sited just below ground level which receive both excreta and flushwater from flush toilets and all other household wastewater. The mean hydraulic retention time in the tank is usually 1-3 days. During this time the solids settle to the bottom of the tank where they are digested anaerobically. A thick crust of scum is formed at the surface and this helps to maintain anaerobic conditions. Although digestion of the settled solids is reasonably effective, some sludge accumulates (approximately 0.03-0.04 m^3 per user per year) and the tank must be desludged at regular intervals, usually once every 1-5 years. The effluent from septic tanks is, from a health point of view, as dangerous as raw sewage and so is ordinarily discharged to soakaways or leaching fields; it should not be discharged to surface waters without further treatment. Although septic tanks are most commonly used to treat the sewage from individual hoseholds, they can be used as a communal facility for populations up to about 300.

A two-compartment septic tank is now generally preferred to one with only a single compartment as the suspended solids concentration in its effluent is considerably lower. The first compartment is usually twice the size of the second. The liquid depth is 1-2 m and the overall length to breadth ratio 2-3 to 1. Experience has shown that in order to provide sufficiently quiescent conditions for effective sedimentation of the sewage solids, the liquid retention time should be at least 24 hours. Two-thirds of the tank volume is normally reserved for the storage of accumulated sludge and scum, so that the size of the septic tank should be based on 3 days retention at start-up; this ensures that there is at least 1 day retention just prior to each desluding operation. Sludge accumulates at the rate of

0.03-0.04 m^3 per person per year and thus knowing the number of users, the interval between successive desluding operations (which are required when the tank is one third full of sludge) is readily calculated.

Septic tank effluent is normally disposed of by sub-surface irrigation in drainfield trenches (soakaways). The drainfield soil must of course be sufficiently permeable. For large flows (from populations above 100) waste stabilization ponds may be more suitable.

With drainfield disposal, the tank effluent is discharged directly to a number of drainage trenches connected in series. Each trench consists of open-joint agricultural drainage tiles of 100 mm diameter laid on a 1 m depth of rock fill (20-50 mm grading). The effluent infiltrates into the soil surrounding the trench which eventually becomes clogged with sewage solids (provision must be therefore made to set aside land for use as a future replacement drainfield). Soil percolation tests should be used to determine qualitatively whether or not the soil is sufficiently permeable. However, the infiltration should not be estimated from percolation test results because they merely indicate the infiltration rate of clean water into virgin soil. The infiltration rate that should be used in drainfield design is the rate at which septic tank effluent can infiltrate the soil surface that has become partially clogged with sewage solids (which form an interface between the soil and the drainage trench). Simple formulae exist to calculate andrelate the various factors involved.

Brief discussion

Septic tanks of the conventional design described above are suitable only for houses which have both an in-house water supply and sufficient land for effluent disposal. These two constraints effectively limit the responsible use of septic tanks to low density urban areas. In such areas they are a very acceptable form of sanitation. However, it is all too common to see septic tanks provided in medium density areas where the effluent, being unable to infiltrate into the soil, is discharged either onto the ground surface, where it ponds, or into street gutters or storm drains; in these cases it causes odour nuisance and encourages mosquito breeding, and is a potential health hazard.

However, it is possible to alter the design of the septic tank to make it more suitable for use in medium density areas (up to approximately 200 people per ha). The design modifications are as follows. The septic tank should be provided with 3 compartments; toilet wastes only are discharged into the first compartment and sullage directly into the second. This arrangement avoids excessive dilution of the toilet wastes with sullage and reduces the hydraulic disturbance in the first compartment, hence minimizing the resuspension of settled excreta and solids carry-over into the second compartment. The third compartment acts as a final settlement chamber before the effluent is discharged into the drainfield. The first compartment should be sized so as to provide 2 days retention time, and the second and third compartment to provide 1 day retention time. Since the effluent from the third compartment contains very few faecal solids (which are predominantly responsible for the clogging of drainage trenches receiving conventionally designed septic tank effluents), the infiltration rate of the effluent is much higher, approximately 30-60 litres/m^2 day. The trench length is correspondingly smaller and thus septic tanks with soakaways become technically feasible, and the need for sewerage obviated, at higher housing densities than is possible with conventionally designed septic tanks. If low volume cistern-flush (or pour-flush) toilets and other water saving fixtures are installed, it is possible to use septic tanks and soakaways at even greater housing densities, perhaps as high as 300 people per ha.

As has been seen with the sewered PF and sewered aqua-privy systems, septic tanks can be used in conjunction with a small-bore sewer network. The tremendous advantages of this are that solids are kept out of the sewers and these can thus be of very small dimensions, laid at virtually flat gradients and require few manholes. This system is ideal for connection to an on-site self-maintaining treatment system in the form of waste stabilisation ponds the effluent from which can be discharged to groundwater without health risk.

1.7 Conventional Water-Borne Sewerage

The conventional cistern-flush toilet is basically a water-seal squatting plate or pedestal unit in which excreta are deposited and then flushed away by 10-20 litres of clean, potable water which have been stored in an adjacent cistern; the cistern is connected to the household water supply and is provided with a float valve so that it automatically refills to the correct volume in readiness for the next flush. The excreta and flushwater are discharged, together with all the other household wastewater into an underground network of sewers for transport to a sewage treatment works or marine discharge station. Alternatively, in low-density areas, they may be discharged into a septic tank.

There are two types of conventional sewerage systems; separate and combined. In the separate or sanitary sewerage system, only household wastwater is transported; stormwater is not permitted to enter the sewers but is drained away into a separate system of underground pipes or into open stormwater drains for eventual discharge into local streams or rivers. In the combined sewerage system, the same network of sewers is used for both sewage and stormwater. Usually, and especially in tropical countries where rainfall occurs seasonally and often with extremely high intensity, it is cheaper to install small sewers for sanitary sewage and separate drains for stormwater, rather than to provide a large combined sewer whose capacity is only fully utilized during periods of intense rainfall and which is liable to have insufficiently high flow velocities to transport excreta in the dry season.

Sanitary sewers are usually made from concrete, asbestos cement, vitrified clay or PVC. They are commonly designed for gravity transport of a maximum or 'peak' flow of 2.5-4 times the mean daily flow and to achieve a 'self-cleansing' velocity of 0.6-1.0 m/s when carrying a flow equal to the mean daily flow. This self-cleansing velocity is required to resuspend and transport any solid material which may have settled out during periods of lower flow (and hence lower velocity). In those developing countries where the use of bulky anal cleansing materials such as corncobs is common and where sand is used for scouring pots, etc., the self-cleansing velocity should be taken as 1 m/s as experience has shown that otherwise blockage of the sewer is common. To achieve a self-cleansing velocity of 1 m/s requires fairly steep pipe gradients; for example a 200 mm pipe (which is the minimum recommended size) must be laid at 1 in 90; in contrast a 100 mm diameter pipe serving a sewered PF toilet need only be laid at 1 in 200 provided the joints are sufficiently tight to exclude groundwater and sand. Excavation and pipe costs for a conventional sanitary sewerage system are thus very high, and can approach twice those for a sewered PF system.

Brief discussion

Conventional water-borne sewerage has certain obvious advantages including high user convenience and (where the system is working perfectly) low municipal maintenance and low health risks.

However, the system has several serious disadvantages:-

- It can only be installed in areas where the houses have at least a single tap in-house level of water supply service. Many urban and most rural communities in developing countreis are without this facility and many will be unable to afford it in the foreseeable future.

- The system is very extravagant with water. It is not uncommon for 60-120 lcd of otherwise unused potable water to be used for flushing the toilet. This is both expensive - amounting to 20-40% of the total annual economic cost of the whole system - and wasteful: large quantities of an often scarce resource are used to transport small quantities of excreta to a treatment works where considerable effort is expended at great cost in an attempt to separate them.

- In areas where the total water use is less than about 75 lcd, the system is prone to malfunction as there is insufficient flow to transport excreta and other solids along the sewers. Blockages are common, especially in areas where bulky anal cleansing materials are used and where other objects (such as items of domestic refuse) are flushed into the sewers. Even in areas where water use is normally above 75 lcd, the system is difficult to maintain during periods of drought.

- The system requires careful and expensive planning and design, tasks often done by expatriate consultants with a consequent cost in foreign exchange. Additionally, since sewers generally have to be laid in fairly straight lines in order to avoid even greater expense and minimise maintenance efforts, it is very difficult and usually impossible to sewer many traditional 'unplanned' housing areas without demolishing a substantial number of houses.

- In hot climates concrete and asbestos cement sewers are highly susceptible to corrosion by sulfuric acid produced by bacteria in the sewer. This corrosion can occur comparatively quickly - within 5-10 years in some environments such as the Middle East.

  Vitrified clay and PVC pipes are not susceptible to this form of corrosion. For sewers above the maximum size of PVC pipe (usually 400 mm) and in areas where PVC pipe is unavailable, concrete or asbestos cement pipes with coal-tar epoxy or pure epoxy coatings are required. The coatings not only require careful application but they are very expensive, approximately double the shelf cost of asbestos cement pipe.

- It is seldom possible to design a sewerage system which operates entirely by gravity flow. Pumping stations have high capital maintenance, and energy costs. Corrosion of steel force mains is another costly problem which requires expensive preventive measures.

- One of the most important disadvantages of conventional sewerage is its costs. The system is extremely expensive compared with all others and is unlikely to be affordable by enormous numbers of people. Whilst a government or municipality may wish to provide conventional sewerage for all its citizens, this can be done only by massive subsidies to the middle and low income majority. This respresents a huge opportunity cost to the national and municipal economy; moreover, if improved health is perceived as the principal benefit of conventional sewerage, it is likely that the desired health improvements can be as effectively achieved by alternative lower-cost sanitation technologies.

  There is little prospect of reducing the costs of conventional sewerage. Even in industrialized countries the system is already designed to minimum standards. Innovative designs of sewer layouts and appurtenances (such as manholes) may reduce construction costs by perhaps as much as 20%, a substantial saving in monetary terms but not one which would put the system within economic reach of the majority of people.

  Frequently, the largest components of conventional sewerage (e.g. interceptor sewers and marine outfalls) have to be designed not for the present population but for the population at the end of their design life (usually 20-50 years). This means that, although all the investment costs are incurred at the start during construction, few of the benefits of the system are accrued immediately on completion; future benefits when discounted back to present day values are relatively small. Moreover, the predicted value of the earliest benefits is generally diminished as householders are often reluctant or unable to invest in the plumbing facilities and pay the usually expensive fee to be connected to the system. Not only is this poor investment economics but it also means that during the initial years when few houses are connected self-cleansing velocities are unlikely to be reached as there is insufficient flow in the sewer; sewer maintenance costs are thus increased.

- Finally, conventional sewerage does not deal with or treat sewage directly (as does the pit latrine for example). It simply transfers that problem elsewhere. Conventional sewage treatment works are frequently an expensive and constant problem and not only in developing countries. They suffer from disadvantages that include:-

i) Poor pathogen removal performance. Effluents from conventional treatment works (based on primary sedimentation trickling filters and secondary sedimentation) contain significant concentrations of viruses, bacteria, protozoa and helminth ova and are thus unsafe for direct agricultural use or for discharge to fresh water bodies - although this is often done.

Conventional treatment has been evolved more for achieving adequate chemical quality (BOD reduction) than for pathogen removal.

This performance can be improved by the use of waste stabilisation ponds and by other tertiary treatment methods.

ii) Very high capital and running costs and, usually, the need for a high imported component.

iii) The need for a high level of maintenance skill.

1.8 Waste-Stabilization Ponds

Waste-stabilization ponds can be considered as an alternative to conventional sewage treatment. They can be employed to service a single housing development or whole sections of towns and are suitable wherever land can be made available.

Waste stabilization ponds are large shallow ponds in which organic wastes are decomposed by micro-organisms in a combination of natural processes involving both bacteria and algae. Stabilization pond systems can treat raw sewage, the effluent from sewered pour-flush toilets or diluted night-soil.

Waste stabilization ponds are the most economical method of sewage treatment wherever land is available at relatively low cost. Their principal advantages in developing countries are that they achieve very low survival rates of excreted pathogens at a much lower cost than any other form of treatment and with minimum maintenance requirements. In fact a pond system can achieve with a high degree of confidence, the total elimination of all excreted pathogens. This is not normally done because the additional benefits resulting from achieving zero survival, rather than very low survival, are less than the associated incremental costs. Waste stabilization ponds are the recommended form of treatment in tropical developing countries where sufficient land is available except when marine discharge is cheaper.

There are 3 types of ponds in common use:-

(1) anaerobic pretreatment ponds, which function much like open septic tanks. They have retention times of 1-5 days and depths of 2-4 m. Design loadings are in the range 100-400 g BOD5/m^2 day; commonly 250 g/m^2

day is used for temperatures above 20°C.

(2) facultative ponds, in which the oxygen necessary for bio-oxidation of the organic material is supplied principally by photosynthetic algae which grow naturally and with great profusion in them. They have retention times of 5-30 days (sometimes more) and depths of 1-1.5 m. Design loadings are commonly 100-400 kg BOD/ha/day, depending on the pond temperature.

(3) maturation ponds, which receive facultative pond effluent and are responsible for the quality of the final effluent. They have retention times of 5-10 days and depths of 1.5 m. They are normally designed on the basis of faecal coliform removal, rather than for BOD removal; very approximately each pond with a 5 day retention time can reduce the faecal coliform concentration by an order of magnitude.

Anaerobic and facultative ponds are designed for BOD removal, whereas the function of maturation ponds is the destruction or removal of exreted pathogens. Thus these three types of ponds should normally be used in conjunction to form a <u>series</u> of ponds. Although it is all too common to see only a single facultative pond treating domestic wastes, this is a totally unsatisfactory design; it is <u>essential</u> to have maturation ponds in order to ensure low pathogen survivals. Thus good designs incorporate a facultative pond and two or more maturation ponds; for strong wastes (BOD's $>$ 400 mg/l) the use of anaerobic ponds as pretreatment units ahead of facultative ponds is often advantageous as they minimize the land requirements of the whole pond system.

Well-designed pond systems, incorporating a minimum of 3 ponds in series and having a minimum overall retention time of 20 days, produce an effluent which will either be completely pathogen free or will contain only small numbers of enteric bacteria and viruses. Pathogenic helminths and protozoa will be completely eliminated. Any bacterial or viral pollution can be reduced or eliminated by adding more ponds to the system. The effluent is suitable for direct reuse or discharge into receiving waters.

Snail and mosquito breeding in properly maintained waste stabilization ponds does not occur. It is associated only with poor maintenance which allows vegetation to emerge from the pond bottom or to grow down the embankment into the pond, thereby providing shaded breeding sites. This can be prevented by providing pond depths of at least 1 m and concrete slabs or stone rip-rap at top water level. The latter strategy also prevents erosion of the embankment by wave action.

Proper and regular maintenance of ponds is simple but nonetheless essential. It consists merely of cutting the grass on the embankments and removing floating scum mats from the pond surfaces.

1.9 Toilet Superstructure

Insufficient attention is frequently given to this aspect of sanitation from a health point of view. Assuming a suitable sanitation technology choice has been made that disposes of and treats human excreta without pathogen risk in the process, the remaining disease transmission risk at the household level is focussed on human contact with the toilet immediately before, during and immediately after defaecation or urination i.e. in or around the toilet superstructure.

The following principles should be followed:-

- <u>the building shell</u>

Assuming that this is contructionally sound, the most important aspects concern light, air and privacy.

Light - as much as possible - should be admitted from the highest points in the walls. This is probably best achieved by leaving large gaps between the tops of the walls and the roof. Daylight is essential for sanitary use, to encourage cleaning maintenance and to not deter children.

Ventilation is essential to dispell odours so that these are not a disincentive to use the toilet. A free flow of air is required, also, to maintain the down-draft principles of the VIP latrine and the ROEC. The required ventilation is best achieved via the daylight appertures described above.

Providing privacy and weather proofing are not infringed, there is no reason why these appertures should not be as large as possible. No savings are made by reducing their size and, therefore, we would recommend that the minimum level presently specified in the Building Code - Grade I (Section 190,(3)(iii)) of 20 sq ins is far too small.

To maintain privacy, prevent rodent access etc., opening should not be left near the floor (e.g. under the door). The bottom of the door should be flush fitting.

- <u>floor finishes</u>

The objective here is to provide a surface that can be easily cleaned with a minimum of water. Bare earth floors should not be allowed under any circumstances as apart from being impossible to clean or replace adequately, they provide ideal environments for certain helminth ova. Similarly, wood is a higher undesirable material for latrine floors.

If concrete is employed, it should be given the smoothest possible finish or, if possible, coated with an alkali-resistant gloss paint.

Floors should be made to slope slightly towards the squatting plate so that removal of water used to wash the floor etc. can be easily disposed of. Under no circumstances should it be made more convenient to sweep this fouled water outside onto the ground and to prevent this, a small step at the base of the door can be incorporated.

- squatting plate materials

From a health point of view, the ideal is to have the squatting plate formed as part of the complete toilet floor unit so as to remove the probability of joins accumulating dirt and pathogens. Where this is not possible, squatting plates should be depressed slightly below the floor level and joined securely.

Several materials are satisfactory including reinforced concrete, ferrocement, sulfar cement, ceramics, glass reinforced plastic (grp), PVC etc. The surface should be as smooth as possible to facilitate easy washing.

Note that reasonably clean household waste water is perfectly adequate for toilet cleaning. Wastewater containing soap or detergent does not prevent the operation of septic tanks. However, the excessive use of disinfectants will.Obviously pit latrines do not benefit from the disposal of wastewater but small volumes of toilet cleansing water will do little harm.

- <u>squatting plate design</u>

The opening should be about 400 mm long to prevent soiling of the squatting plate and at most 200 mm wide to prevent children falling into the pit. A "keyhole" shape is suitable.

Foot-rests should be provided as an integral part of the squatting plate and properly located so that excreta fall into the pit and not on to the squatting plate itself.

The free distance from the back wall of the super-structure to the opening in the squatting plate should be in the range 100-200 mm; if it is less there is insufficient space, and if it is more then there is the danger that the rear part of the squatting plate will be soiled. Generally, the preferred distance is 150 mm.

The squatting plate should have no sharp edges to make its cleaning difficult and unpleasant.

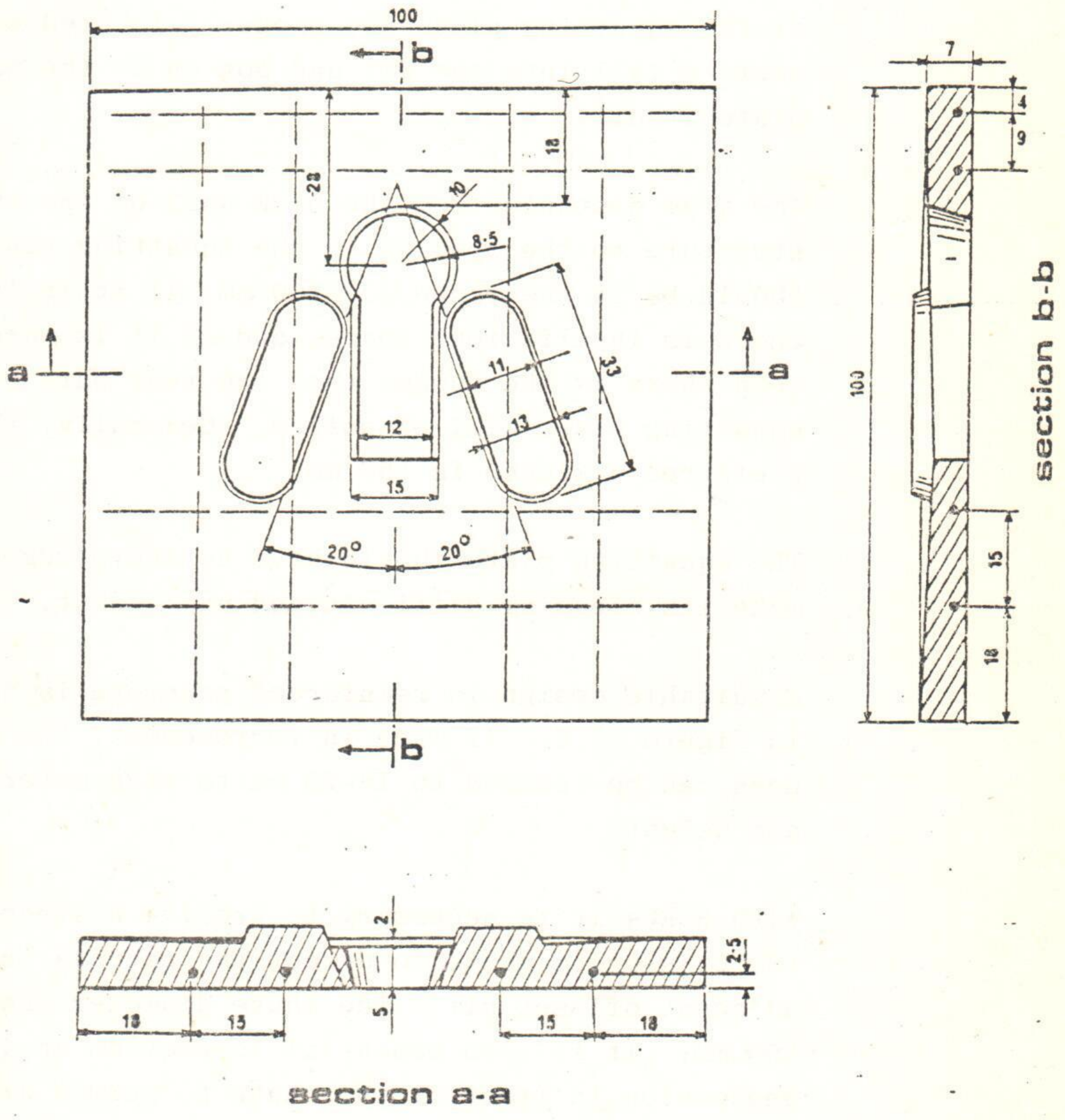
A suitable design in reinforced concrete is shown in Figure II.6. If made in ferrocement, the thickness can be reduced to 18-25 mm to save materials and weight.

With ROECs it is necessary to provide a steeply ($60^{o}C$) sloping chute to direct the excreta into the adjacent off-set pit. The chute diameter should be 200 mm. It is also essential to provide an inclined depression in front of the chute to permit urine to drain away satisfactorily. It is possible, but rather difficult, to cast the chute in ferrocement as an integral part of the squatting plate; in practice it is easier to use metal or PVC pipe cut to shape.

A basic design for a squatting plate suitable for a pour-flush system with completely off-set pit is shown in Figure II.7.

Figure II.6

CONCRETE SQUATTING PLATE



measurements in mm

Source: (From Wagner and Lanoix)

Figure II,7

SQUATTING PLATE AND WATER SEAL UNIT DETAILS FOR INDIAN P–F TOILET
WITH COMPLETELY DISPLACED PIT

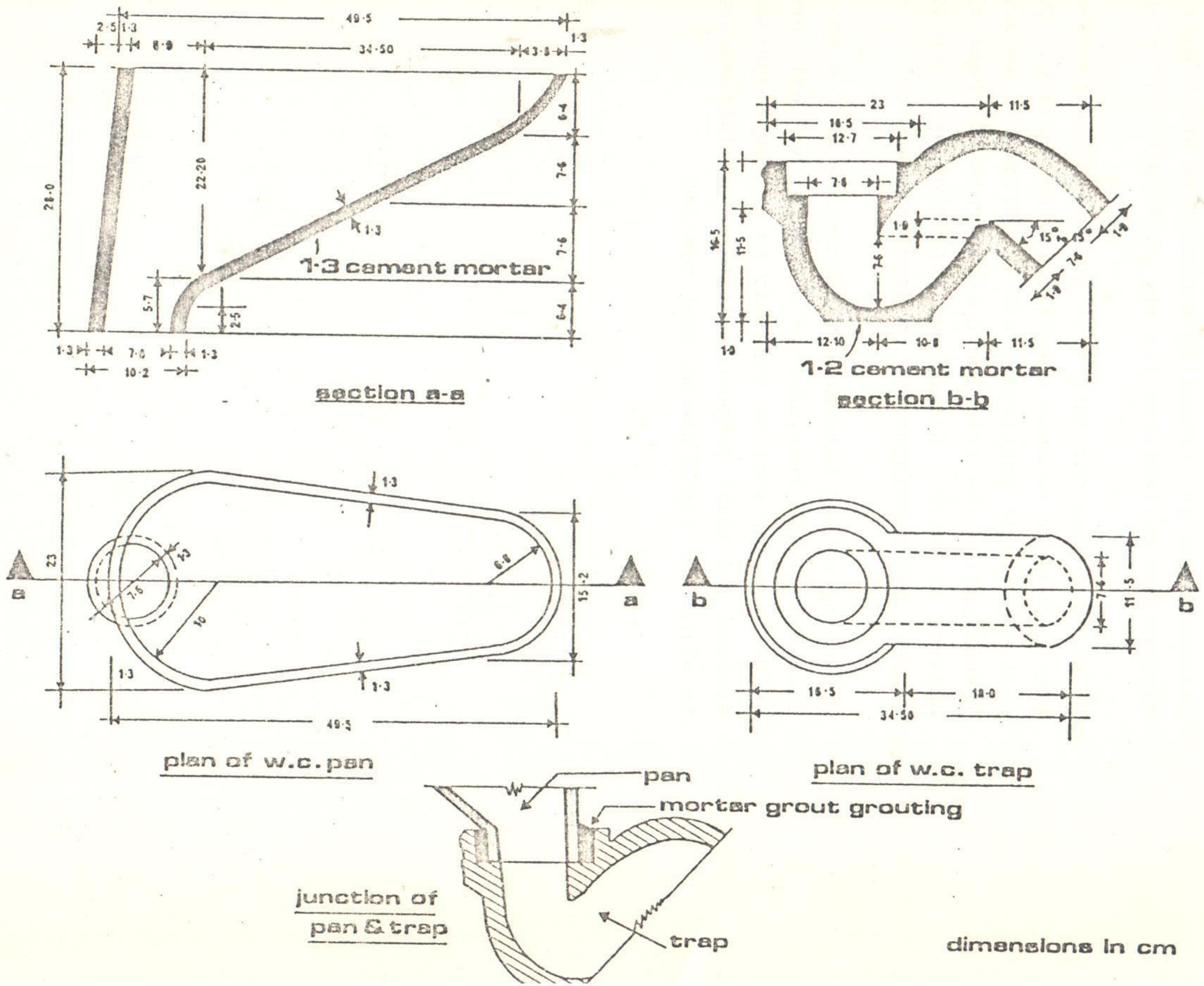


Figure II,7

1.10 Summary

It can be seen then that each of the main distinct variations for sanitation technology has its advantages, disadvantages and operating constraints which will dictate its suitability for any particular situation.

It has not been our intention at this stage to draw conclusions or to make specific recommendation. Our work on this is continuing and in particular we are investigating the relative cost factors of these alternatives in Kenya. Rather our intention has been to present basic information to focus discussion.

Depending on the outcome of discussions and on the findings of the remainder of our work, we shall propose guidelines for what we consider to be Kenya-appropriate systems and shall propose suitable legislative change to allow the legal use of such systems.

2. WASTE-WATER DISPOSAL AND SURFACE DRAINAGE

The adoption of on-site excreta disposal technologies such as improved latrines, ROECs etc. (but excluding septic tanks) requires that separate facilities be provided for sullage disposal. Sullage is defined here as all domestic wastewater other than toilet wastes; it is thus the wastewater from showers and sinks and includes laundry and kitchen wastes as well as water used for personal washing. It contains some excreted pathogens; per capita contributions of enteric indicator bacteria in excreta are 10^4 to 10^5 higher than those in sullage. Sullage also contains a variety of organic compounds, most of which are readily biodegradable (with the notable exception of 'hard' detergents if these are present in locally manufactured washing powders). Approximately 40-60% of the total household production of waste organics (excluding garbage) is associated with sullage - that is, some 20-30 g BOD5 per capita per day (gcd). This figure, however, depends on water consumption; a family with suitable facilities and abundant water for personal and clothes washing will obviously generate more sullage BOD than one which obtains only small quantities of water for drinking and cooking purposes from a public standpipe.

The volume of sullage generated is also clearly related to water consumption. In many industrialised countries sullage accounts for 50-70% of total domestic water use, the balance being used to flush cistern-flush toilets. A similar situation undoubtedly exists in the more affluent communities in developing countries (although there are no data available), and it can be safely assumed that in communities which have a water consumption of 200-300 lcd and cistern-flush toilets the volume of sullage generated is approximately 60% of the water consumption (excluding garden watering). With other (less affluent) urban communities in developing countries, the prediction of sullage volumes is more difficult. However, tentative estimates are as follows:

(1) In households with a hand-carried water supply (obtained from public standposts or vendors) and pit latrines or compost toilets, sullage generation may be conservatively estimated as the water consumption; that is, normally around 20-30 lcd.

(2) In households with a on-site single-tap water supply and pour-flush toilets or vaults, the sullage volume can also be taken as the water consumption (excluding that used for garden watering and the 3-6 lcd flushwater); that is, normally about 50-100 lcd.

Local figures should be used in any site - specific calculations.

In contrast, it is very time consuming to obtain good estimates of the daily per capita BOD contribution in sullage. Where no data on this are available it is probably reasonable to estimate 5-10 gcd and 15-25 gcd for communities which have hand-carried and on-site water supplies respectively. Thus the BOD of sullage is probably in the approximate range of 100-350 mg/l. The use of plumbing fixtures designed to reduce water consumption will of course increase these concentrations.

In developing countries sullage is therefore a wastewater with approximately the same organic pollution potential as raw sewage in North America. Indeed there are many canals and streams in urban areas of developing countries which are grossly polluted (BOD up to 250 mg/l) by sullage. Indiscriminate sullage disposal not only damages the environment but also has sometimes serious public health consequences.

There are basically four kinds of sullage disposal systems:

(1) casual disposal by tipping in the street, houseyard or garden;

(2) on-site disposal in ground seepage pits;

(3) disposal in open drains (commonly stormwater drains);

(4) disposal in covered drains or sewers.

Each system has different health risks and these are reviewed below preceding the discussion of design considerations.

Health Aspects

Tipping sullage on the ground in backyards or gardens may create breeding sites for Culex pipiens (see Appendix 1) which is a cosmopolitan nuisance mosquito and also the vector of bancroftian filariasis. It may also create muddy and insanitary conditions which could help to promote the development of helminth ova which require a fairly moist environment. A clean dry yard is less likely to be used for defaecation by children, and any ova deposited are unlikely to develop. A wet muddy yard will conceal any faeces deposited and will promote development of worm eggs and larvae. There is evidence that families whose yards are clean and dry (due to hygienic practices and/or soil types) have lower intensities of Ascaris infection than do other families. Sullage containing pathogens from babies' bathwater or adults' ablution water may infect children playing in the yard. In permeable soils or where evaporation is high, and where sullage production and housing density are low, tipping of sullage on to the ground is unlikely to be a significant health hazard. However, where the soil is less permeable and evaporation low, and where either water use or housing density is high, an alternative method of sullage disposal becomes essential.

Sullage disposal in properly designed and constructed ground seepage pits causes only a low risk of groundwater contamination because the risk of microbiological and nitrate pollution of groundwater from sullage is very much lower than it is with sewage, since sullage contains far fewer pathogens and much less nitrogen.

Sullage disposal in open drains, such as stormwater drains, provides the most readily identifiable potential health risk - namely that of promoting the breeding of Culex pipiens and other mosquitoes where these are a risk. Assume that sullage is being introduced into the stormwater drainage system. In areas of year-round rainfall, these drains will contain water continuously. If they are kept free of garbage and are well designed they will flow freely and provide few sites for mosquito breeding. The presence or absence of sullage will make no difference. However, in areas of seasonal rainfall, or where the drains are liable to become blocked with garbage, the addition of sullage will create year-round water and thus year-round Culex breeding where previously only seasonal breeding may have occurred. Here it is not the quality of the sullage which is important, since ponded stormwater would also be sufficiently polluted to allow Culex pipiens breeding, but it is rather the continuous production of sullage which may have the effect of converting wet season breeding into year-round breeding in areas where the stormwater drains are liable to pond. The change from wet season breeding to year-round breeding may have a considerable impact on filariasis transmission, and in some cases it may lead to increases in both the prevalence and intensity of the infection.

Sullage disposal in closed drains or sewers is expensive, but has no special health problem unless it is eventually discharged without treatment into a sluggish or ephemeral stream where it may promote Culex breeding. The disposal of sullage, along with excreta, into sanitary sewers also presents no additional health risks, but this is in itself no justification for the provision of conventional sanitary sewers.

Engineering Design

Seepage pits

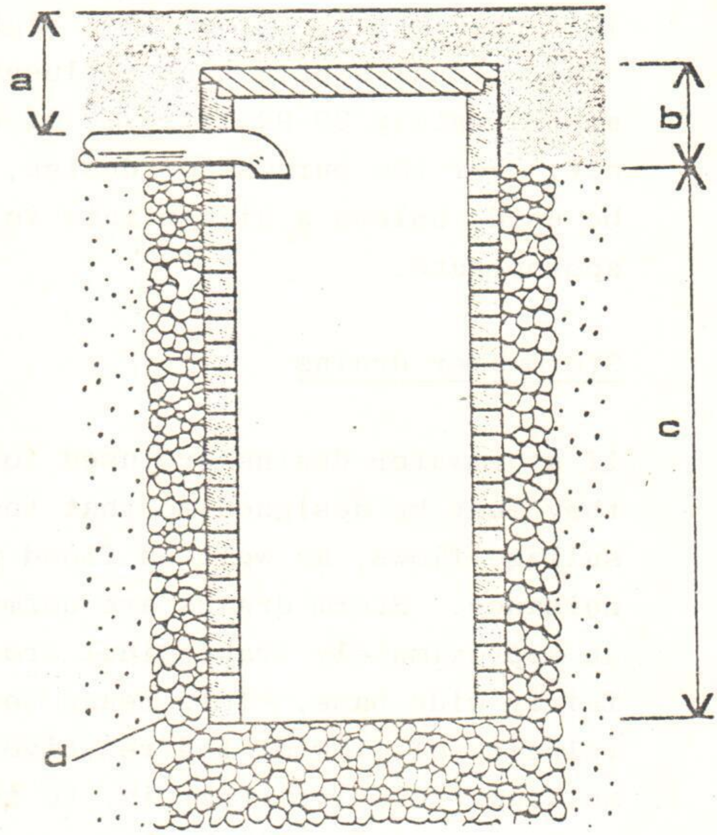
A suitable design for a seepage pit for use in permeable soils is shown in Figure II.8. The pit may be circular, square, rectangular, or even irregular in plan, to suit the space available. The side walls may be lined with open brickwork, or unlined and filled with rock (50-100 mm grading) or brickbats. The rate of infiltration of sullage is approximately three times higher than that of conventional septic tank effluent; that is, approximately 30-90 litre/m^2 of sidewall area per day. For the purpose of design, 30 litre/m^2 should be used, unless a higher rate is known to be more appropriate.

Stormwater drains

If stormwater drains are used for sullage disposal they must be designed so that they can handle low sullage flows, as well as flood peaks, without nuisance. Storm drains are normally designed with an approximately trapezoidal cross-section with a fairly wide base. This means that the depth and velocity of flow of the relatively small amounts of sullage (relative, that is, to the drain's storm-water capacity) will be low, and the risk of blockage and ponding high. If the storm drains are already in existence and lined, it is advisable (but somewhat costly) to modify the channel section as shown in Figure II.9 so that the sullage can flow with a higher velocity in the central section only. If the drains are not already lined, it would be advisable to line at least the base incorporating a reduced central section as shown. If surface drainage is to be provided at the same time as the improvements in excreta and sullage disposal, it

FIGURE II, 8

SULLAGE SEEPAGE PIT

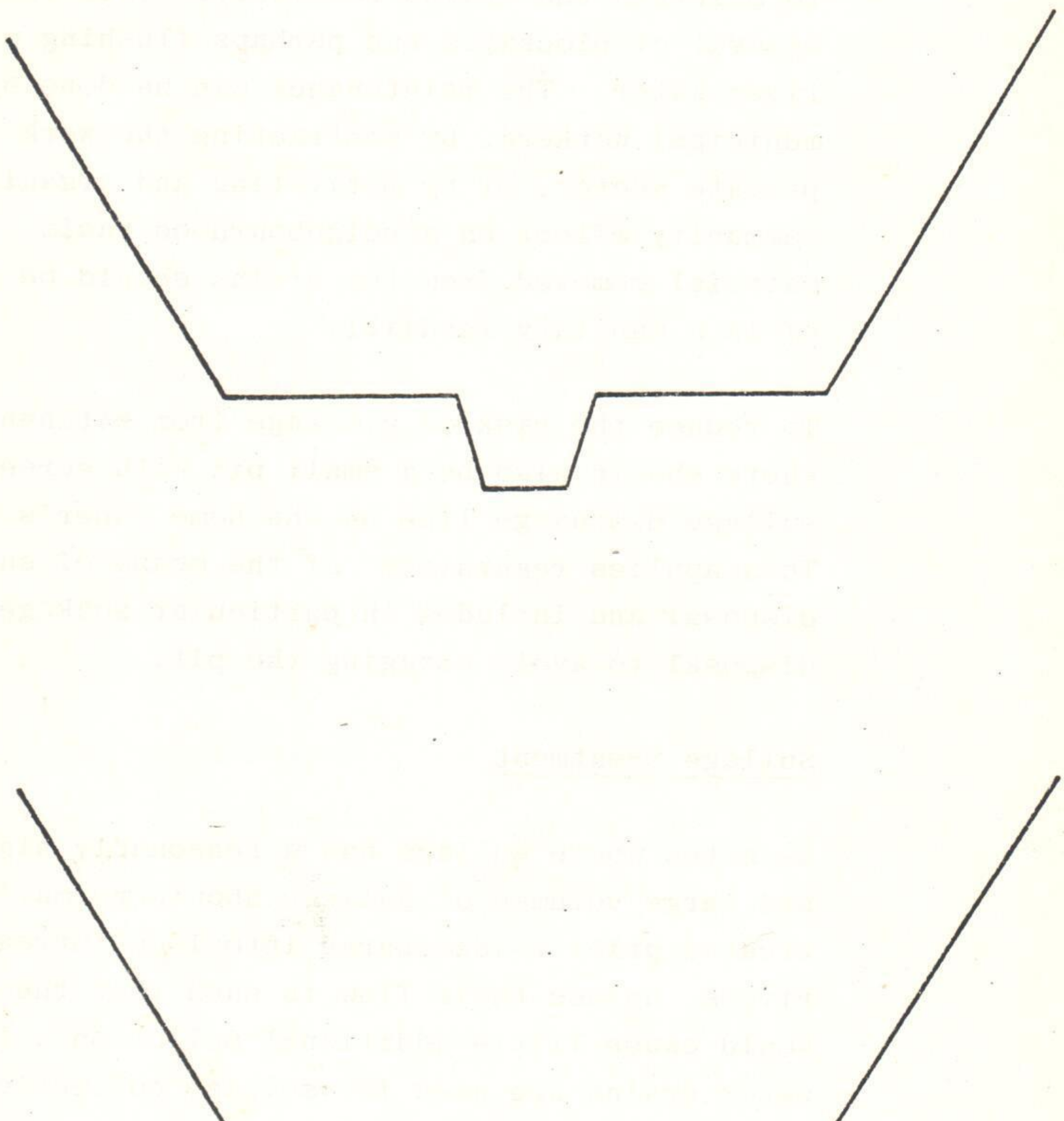


Key:
A: Variable Cover of Soil
B: Tight Joints
C: Open Joints
D: Rock Fill (150 mm Minimum)

Source: (From Wagner and Lanoix)

FIGURE II, 9

MODIFICATIONS TO STORM WATER DRAINAGE CHANNEL GEOMETRY TO PERMIT INCREASED SULLAGE FLOW VELOCITIES



may be advisable to consider alternative channel sections such as triangular ones; these should be lined at the apex in order to provide higher sullage velocities and minimize erosion and blockage.

Whatever channel section is adopted, it is necessary to maintain the drains routinely. This includes removal of blockages and perhaps flushing with river water. The maintenance can be done by municipal workers, by contracting the work to the private sector, or by motivating and organizing community effort on a neighbourhood basis. The material removed from the drains should be disposed of in a sanitary landfill.

To reduce the risk of blockage from kitchen water, there should also be a small pit with screen on the sullage discharge line on the home owner's property. This applies regardless of the means of sullage disposal and includes in particular soakage pit disposal to avoid clogging the pit.

Sullage treatment

As noted above sullage has a reasonably high BOD, and large volumes of sullage should normally be treated prior to discharge into local streams or rivers, unless their flow is such that the sullage would cause little additional pollution. If stormwater drains are used for sullage collection these should discharge into a single facultative waste stabilization pond which is normally the most convenient method of treatment wherever land is available. Maturation ponds are not necessary as the concentration of excreted pathogens in sullage is small. The pond should be protected from high stormwater flows in the wet season by incorporating a simple stormwater overflow weir into the pond inlet structure.

3. WATER SUPPLIES

From the observations made in Appendix I, it is clear that water is the key to breaking the transmission cycle of a large group of diseases. Most of the major faecal-oral transmission routes can, in theory, be interrupted directly by hand washing after toilet contact and before food contact. A reduction in these excreta-related diseases will have other positive spin-offs, for example in a likely reduction in severity of some upper respiratory diseases through the improved nutrition that a reduction in diarrhoeas and helminth diseases will achieve.

Although many or most of the excreta-related diseases can be transmitted via the water supply, when this occurs it tends to be associated with an explosive outbreak resulting from a defective supply or contamination at some point on the distribution network for example where intermittent supply introduces contaminated groundwater into a pipe. Far more frequent is the day to day endemic occurance of excreta-related disease that is not water-borne but where transmission occurs by a more direct faeces-hands-mouth or faeces-hands-food-mouth route. It is for this reason that the availability of sufficient water for personal hygiene is the key issue.

Protection of the water supply is, of course, important but is an often over-rated source of infection. In any case this is not the concern of housing authorities apart from ensuring that on-site contamination does not occur. Of far more importance, is the influence over and control of what happens to that water once it leaves the tap and ensuring that it is available in sufficient quantities to facilitate personal hygiene.

The issue of water and health therefore should start from a consideration of how much water is required to keep a human being healthy. Unfortunately, very little conclusive evidence is available on this point. However, the question immediately points to the importance of the inter-dependencies of water and sanitation choice. The individual who is disposing of 30-40 litres of water a day in his cistern-flushing, water-borne sewer system 'needs' that much more than his neighbour with an aqua-privy.

Cairncross and Feachem (1978) suggest that water consumption can be expected to be in the region of 20 litres per capita per day (lcd) where it is carried from a standpipe as opposed to 80 lcd when available from a single tap in the home.

In analysing data from surveys of low cost housing areas in Kenya (Waweru <u>et al</u>, 1976), de Krujff arrives at an average consumption of 13.7 lcd where water is obtained from kiosks.

In a study of Mathare Valley, Linn (1976) shows an average consumption of 10-11 lcd.

In a recent study of water use in low-cost housing areas in Kenya, de Krujff maintains that health benefits from water use begin to level out somewhere between 30-80 lcd depending on the type of sanitation system in use and its water consumption needs.

Certainly, Bannaga (1977) found in a six month monitoring of households in western Sudan that there were few health benefits obtained above the level of 60 lcd.

In fact the figure of 60 lcd is often taken as a rough guideline of water needs but it should be emphasized again that this depends on the type of sanitation system.

<u>Standpipe supply</u>

Taking this as a rough guideline, however, it is easy to see one of the main disadvantages with standpipe or kiosk supply. A family of five, say, requires then 300 lcd. Ignoring even the cost factor involved (kiosk water is roughly twice as expensive as household water), it is evident that the carrying of 300 lcd from the standpipe to the house is a tremendous burden - indeed consumption will be reduced for this reason alone.

There are other, equally serious problems with standpipe supply. The water taken to the house is in buckets, plastic cans or other containers and is then either put into a storage container or remains in the carrying container. Either way, the use of that water for hand washing is extremely inconvenient. It also introduces risks of contaminating the stored water itself during the process of pouring, refastening lids etc.

Stored water offers many opportunities for contamination from hands and utensils used to take water from the storage container. Many excreta-related diseases can be very effectively spread in this way.

Although of course water from a standpipe is better than no water at all, it is vastly inferior from health considerations than that from a household supply. In view of the large range of common diseases associated with lack of water for washing, we would maintain that water to the house is a top priority and that many other items should be sacrificed in order to achieve this basic need.

<u>Household supply</u>

The key problem with water provision in low-income areas is that of achieving a balance between raising water consumption to health-effective levels whilst keeping capital and recurrent costs down.

It is not the intention of this paper to deal specifically with the economic or engineering aspects of water provision. However, it should be noted that some very sensible suggestions of how this balance can be achieved have recently been put forward by de Kruijff (1979). It is maintained that using household "Fordilla" self-closing taps, appropriate engineering, flat rate water charges collected in the general rate, rent or loan repayment procedures etc., it is economically feasible to supply all low-income families with household water.

These findings are of the greatest importance to health and should be tested and implemented.

4. VENTILATION AND CLIMATIC COMFORT

From the discussion in Appendix I, we conclude that the issue of ventilation is a much over-rated one as far as health is concerned. It is impossible to show that improved ventilation achieves a reduction in disease transmission.

Much airborne infection - particularly the childhood diseases - is inevitable. Even if houses were constructed to the standards of operating theatres cross-infection would still occur through close personal contact and outside the home. Indeed we have argued that it is undesirable to attempt to reduce transmission risks for such inevitable disease since this will only result in infection later in life with more serious consequences. Several more serious airborne diseases can be made non-inevitable through artificial immunity and efforts are better directed towards vaccination programmes. Earlier and more effective treatment after infection would achieve reduction in seriousness for some diseases. Better nutrition would also reduce disease seriousness for some airborne infections.

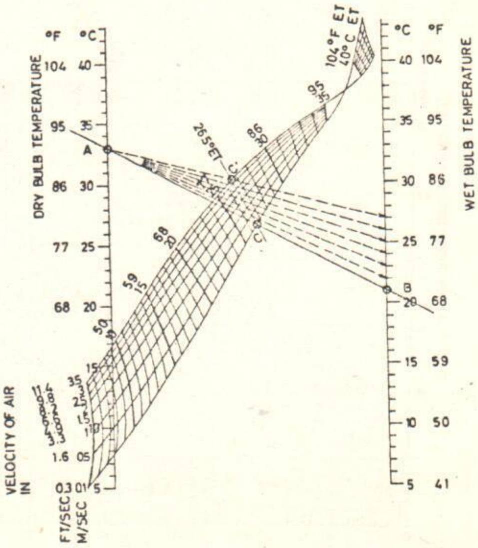
We therefore maintain that standards of ventilation are impossible to devise and that spurious standards should not be used to prevent house construction. Controlled legal housing offers the very opportunities for immunisation, treatment and better nutrition through improved socio-economic circumstances that we should be seeking.

However, ventilation is concerned with human comfort levels. The ability to open doors and windows and to close them again to regulate the house environment is an obvious necessary quality. Similarly, daylight is a necessary factor for indoor activity - the more so where, as in low-cost housing, electric light is unaffordable - and is probably an incentive for maintaining house cleanliness.

It has been suggested (Demeter and Lippsmeier <u>et al</u>, German Research Foundation, 1973) that in the vicinity of the equator, the 'comfort zone' ranges from about 22.5-29.5^{o}C temperature and from 20-60% relative humidity.

Many attemtpts have been made to devise a single measure which would sum up the main factors of 'climatic comfort'. Houghton and Yaglon (1923) proposed the concept of 'Effective Temperature' (ET) to combine the effects of actual temperature, humidity and air movement.

The determination of 'Effective Temperature' can be made using a simple nomogram as shown below.



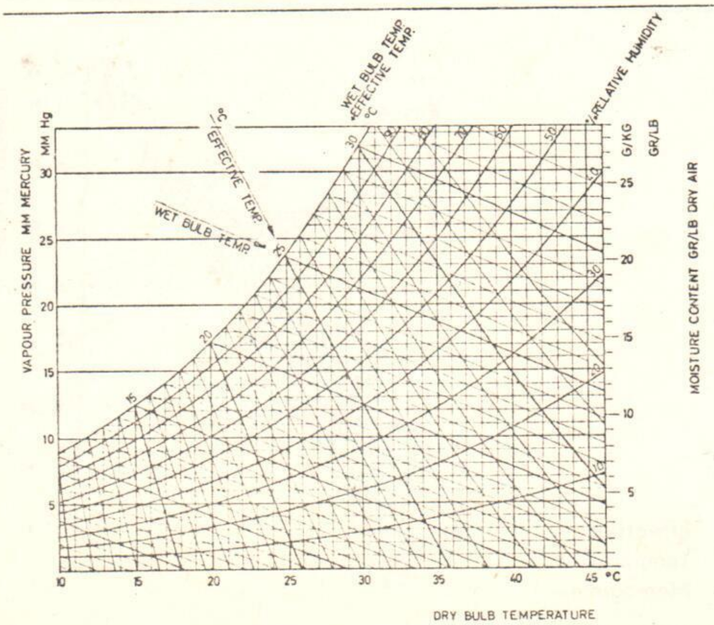
Effective
Temperature
Nomogram

Knowing values for dry bulb and wet bulb temperature, a line is drawn between the two values. The example shown above connects 33°C dry with 21°C wet. Where this line intersects the curves for air velocity (e.g. 0.1 m/sec) the 'Effective Temperature' (ET) can be read off (i.e. 26.5° ET in the example).

The same series of tests indicated a 'comfort zone' in tropical conditions in the region of 19-26° ET (a little higher for arid areas). Most people begin to perspire noticeably at about 26° ET and at 26.5-30° ET human resistance and efficiency begin to fall markedly. A very difficult environment is found between about 33.5-35.5° ET and an impossible one beyond 35-36° ET.

Similar methods to the above have been developed by the Medical Research Council, London.

In a similar way, a series of nomograms can be constructed for different air movement levels. That shown below is for air movement of 0.1 m/sec. This nomogram also introduces measures of relative humidiy, air moisture content etc.



Knowing the required environmental data then and fixing an upper desirable 'Effective Temperature' (26^{o} ET, say), a nomogram like the first of those above can be used to calculate a required minimum air movement rate.

In practice, however, this is only a partial solution. The designer wishes to know how he should design a dwelling to achieve that air movement and there is no short-cut to this except experiment - models, wind tunnels etc. To be realistic, this would have to be done for every proposed design, inter-house spacing, orientation to prevailing winds etc.

Unless experimental facilities are available, therefore, the designer is obliged to fall back on experience and what is known about the broad principles of house ventilation (see for example, Koeningsberger et al, United Nations 1971; Koeningsberger and Lynn, 1965; Givoni 1965; Goromosor 1965; Van Straaten 1967; Olgyay 1963; Adeeb 1966 etc.

Adequate ventilation is, of course, particularly appropriate in the humid coastal and Lake Victoria areas. Good basic design principles aim to achieve:-

- a low level entry point for air flow to achieve good air movement at body level; combined with

- high exist points to achieve maximum negative pressure effects (where low level flows over the site are constricted by buildings, walls, fences, trees etc.).

- the avoidance of 'dead space' between roof and ceiling or in the high areas of the roof if ceilings are not built.

On this latter requirement, ventilation openings between roof overhangs and the tops of walls are essential in hot, humid regions. It should be borne in mind, however, that these provide ideal entry points for mosquitoes if no ceilings are provided. To satisfy this problem all that is essentially required is a ceiling in some stretched material or netting rather than a solid construction.

5. 'BAREFOOT' MAINTENANCE TECHNOLOGIES

From the epidemiological discussions of Appendix I and from the earlier sections of this present Appendix, it is clear that organisational, educational and maintenance factors are at least as important as the physical provision of infrastructure.

To be successful, low-cost housing relies heavily on levels of organisation above those of the individual household. It is clear, however, that public authorities are already over stretched with maintenance workloads and suffer from staff shortages etc. Since there is little short-term prospect of dramatic improvement in this situation, it is clear that new, creative solutions must be sought.

One area in which such solutions might be sought is in more community involvement through the development of 'barefoot' technicians.

The term 'barefoot' comes from China where a system of 'barefoot doctors' was developed to compensate for the shortage of conventional doctors. These 'barefoot' medical auxiliaries were selected from suitable candidates from each village, given a basic practical (non-theoretical) training and returned to their villages under routine supervision of the health authorities. There, they continue with their normal jobs, practicing their medical skills as needed. Small additional payments are made to these workers to compensate for time lost from their normal occupational activities.

The concept has been adopted in many other parts of the world in the health field but an added incentive was provided by the success of the Chinese system. It was shown that with a minimum training, these workers could provide a successful system of basic primary medical care.

Additional benefits soon became apparent. First it was discovered that, far from being second rate doctors, these workers provided something that doctors did not - namely knowledge of their village populations. They became trusted and valued citizens without any of the 'social distance' that normally exists between village populations and highly educated doctors from a different social class. Secondly, themedical auxiliary movement has given rise to new diagnostic and clinical management techniques which now have benefits for the more traditional professionals in health care.

This is not the place to go into detail about the medical auxiliary but the analogy with the low-cost housing problem is clear. Why cannot a small number of site allottees be given a simple course of intruction and paid small amounts to provide certain community functions in addition to their main jobs?

Such a 'barefoot sanitary engineer' could provide useful work in areas such as:-

- the maintenance of excreta disposal systems on the site on which he lives. All systems require a degree of maintenance of some kind from advice and arrangements for the emptying of pit latrines to the unblocking of conventional water borne sanitation systems;

- the maintenance of surface water drains;

- maintenance of waste stabilisation ponds;

- maintenance of solid waste disposal; etc.

An important benefit of the 'barefoot' concept is that residents see a responsible person. They know who to complain to. For incidents beyond the abilities of the 'barefoot' worker, at least he is in contact with authorities to effect suitable arrangements or repairs.

Considerable opposition to such an idea can be anticipated from various professional bodies just as the medical profession was vigorously opposed to the 'barefoot' doctor. But if these authorities are unable to provide the necessary services in conventional ways, they must be convinced that realistic alternatives are available.

Some experiments in this concept would be timely and fully consistant with the national philosophy of 'harambee'.

APPENDIX II

COMMENTS ON THE LEGISLATION

DRAFT

APPENDIX III

Comments on the Local Government (Adoptive By-Laws) (Building) Order 1968 (Grade I By-Laws). The Local Government (Adoptive By-Laws) (Grade II Building) Order 1968 (Grade II By-Laws) and their compatibility with the Public Health Act 1972, the Local Government and the Drainage and Latrine Rules and each other.

Applicability.

Both Grade I and Grade II By-laws are adoptive by any municipal or county council. This By-law 2 leaves out a number of other local authority who appear in effect to be using the Building Code (i.e. Grade I and II By-laws). It seems that Grade I rules are being used by many authorities whether they have been adopted or not. However, it seems clear that under the Local Government Act Revised 1978 Section 4, all local authorities are either Municipalities or County Councils. The City of Nairobi is included as a municipality under 4 (a). It also appears that all lesser authorities derive their existence from the County Councils.

The Public Health (Drainage & Latrine) rules have been applied to certain local authorities but not all (see note on Subsidiary Legislation page 1).

The Public Health Act and the Local Government Act apply to all areas of Kenya.

As far as applicability is conerned, generally the Grade II By-laws would apply to scheduled areas within municipal or county councils who have adopted them. However, this would apply to specific matters actually included in the Grade II rules and where these are silent, then senior rules would apply and finally an Act.

Housing and Public Health Legislation.

General

The main statutory instrument is the Public Health Act.

Important subsidiary legislation is contained in:-

The Building Rules 1962 (Have they been repeated?)

The Public Health (Drainage & Latrine) Rules, 1948

The Public Health (Kisumu Density of Dwellings) Rules 1948

The Public Health (Medical Officers of Health and Health Inspectors) Rules, 1963.

In addition there is the Building Code containing:-

(1) The Local Government (Adoptive By-laws) (Building) Order 1968.

(2) The Local Government (Adoptive By-laws) (Grade II Building) Order 1968.

The Building Code is subsidiary legislation of the Public Health Act but made under regulation 210 of the Local Government Regulations 1963 by the Minister for Local Government in accordance with Section 126A(5). The Building Code does not have the force of law until the Adoptive By-Laws are adopted by any municipal or county council. This is not obligatory but permissive only.

Under Section 126A of the Public Health Act local councils may and shall if required by the Minister for Local Government (with the agreement of the Minister of Health) make by-laws as regards buildings, works and fittings, the planning procedure, the inspection of works and alterations. No by-law can be inconsistent with any written law in force in the same area made under any other provision of the Public Health Act. It must be presumed that the Building Code has the agreement of the Minister of Health. We need to know which councils have adopted the Building Code and whether any amendments or additions have been made by individual councils.

It remains to ensure that there has been no subsidiary legislation relevant to housing since 1972.

The Public Health Act (Revised 1972) CAP. 242.

The relevant sections are as follows:-

Preliminary

Section 2. Interpretation.

This section contains a series of definitions relating to housing which are repeated to some extent in subsidiary legislation. The interpretations are the crucial ones and take precedence over any in subsidiary legislation if the latter are incomplet or obscure.

Thus interpretations require speical noting. "drainage authority" means the Ministry of Works or any other authority the Minister of Health may appoint for any particular area. Note: The Minister has presumably appointed the Engineering depts. in Nairobi, Mombasa, Kisumu and perhaps others.

"health authority" in relation to the area of a municipality means the municipal council of the municipality concerned, and, in relation to any other area, means the Minister of Health.

PART II Administration

Section 10 (2)

Included in the legal functions of the Medical Department; "to advise and direct local authorities in regard to matters affecting the public health."

Section 13

Sets out the duties of health authorities in general terms.

Section 14

Allows for the failure by a municipal council to exercise its powers and duties for these to be undertaken by default by the Minister of Health.

Section 15

Refers to agreement of the Minister of Health being necessary when any by-laws relating to Public Health are to be approved by the Minister for Local Government.

Section 16

Makes it clear that the Public Health Act has overiding authority with regard to any law made under other Acts relevant to health.

PART III Notification of Infectious Diseases

Nothing specifically relevant.

PART IV Prevention and Suppression of Infectious Diseases

Section 21

Gives right of entry to M.O.H.

Section 22

Cleansing and disinfecting of premises by the health authority.

Section 23

Allows for the destruction of infected buildings on the medical officer of health's authority. Compensation.

Sections 30, 31

Infected house may not be let. True information must be given to prospective tenant.

PART IX Sanitation and Housing

This is of course the most relevant part, it is the final authority where doubt exists in any subsidiary legislation and the only authority where subsidiary legislation does not exist.

It extends from Section 115 to 126C.

Section 115

No person shall cause a nuisance or allow one to exist on land or premises owned or occupied by him. Or other condition liable to be injurious or dangerous to health. Nuisances are specified in Section 118.

Section 116

Every local authority is oblied to maintain its area in clean and sanitary state and to prevent nuisances occuring. The L.A. is empowered to prosecute offenders.

Note: No mention is made of the funds necessary to perform these functions. Any penalties are paid in to the treasury presumably.

Section 117

This section relates particularly to the duty of the L.A. for preventing or remedying any conditions arising from the following:

Erection of unhealthy dwellings

Occupation of unhealthy dwellings or premises.

*Erection of dwellings on unhealthy sites

Erection of dwellings on sites of insufficient extent

Overcrowding

Erection, condition or manner of use of factory or trade premises.

Section 118

This lists 19 causes of nuisances. The ones relevant to housing are:-

(b) A dwelling so constructed or in such condition which in <u>the MOH's opinion</u> is dangerous etc. to health or liable to spread infectious disease.

(c) Refers to situations in the <u>external environment</u>. Likely to be <u>offensive</u> or dangerous etc. to health. Includes. Streets etc., streams, gutters etc. latrines etc. Dust bin, refuse pits etc.

*(d) Water. Used domestic or any drinking purpose. Opinion of the MOH polluted or injurious or dangerous to health.
<u>Note</u>: Really applies to drinking water only.

(e) Above would cover standing water liable to breed vectors carrying disease and nuisance insects.

(e) Discharge of noxious or other waste into public street or any public waterway.
<u>Note</u>: Prohibits household? being put into open drains. (vide Lamu).

*(h) Accumulations of refuse constitues a nuisance.

*(i) Any accumulation of building materials if MOH thinks is likely to harbour rats etc.

*(j) Premises likely to harbour rats.

(k) Overcrowding - being injurious etc to health.

Dilapidated.

Defective in lighting or ventilation.

Not provided with sanitation.

Situated so sanitation cannot be provided to the satisfaction of the MOH.

Note: A very important subsection. It all depends upon interpretation especially overcrowded premises. Lighting, ventilation and sanitation standards are specified in subsidiary legislation.

(m) Any occupied dwelling without proper, sufficient and wholesome water is not available within a reasonable distance.

*(p) Any area of land kept or permitted to remain offensive, liable to cause disease, injurious etc.

(s) Any act, omission or thing which is or may be dangerous to life or injurious to health.

Note: (s) is quoted in full. No one's opinion is required therefore depends upon the Courts. A let out clause.

Section 119

Sets out the methods to remedy or remove the nuisance. Duty of the MOH.

Owner responsible for structural defects or where the occupier cannot be found.

MOH can remedy where the author of the nuisance cannot be found or where the nuisance does not arise from the actions of occupier or owner.

Section 120, 121, 122

Procedure if nuisances not remedied.

Penalties. Court procedure and powers.

Section 123

Rights of entry for examining of nuisances.

Section 124

Demolition as the result of a nuisance and so dilapidated or so defectively constructed or so situated repairs not likely to remove nuisance or render dwelling fit for habitation. (The Court decides not the MOH or his staff who give evidence). One month at least notice to demolish. No compensation. The section details procedure.

Section 125

Medical Department has the duty to survey overcrowding bad or insufficient in the various districts of Kenya.

Inquire into best methods of dealing with overcrowding or bad housing. Publish recommendations.

Note: This would now appear to be more in the province of the Ministry of Housing.

*Section 126

This empowers the Minister of Health, with the advice of the Central Board of Health to make rules and confer powers with regard to implementation on local authorities, magistrates, owners and others. These include:-

(a) Land, dwellings, buildings etc. free from nuisance or danger to P.H.

(b) Construction buildings, lighting and sanitation, overcrowding.

(c) Cleansing, whitewashing or other treatment.

(d) Drainage and disposal of waste.

*(e) Sub-division and lay-out of land for building sites.
Street levels etc.
Limitation of numbrs of dwellings
Proportion of site to be built on
Zoning

(f) Inspection by L.A. for public health purposes.

Note: Subject to any rules that may have been made after 1972, the Minister of Health has only made rules as referred to above. It should be noted that the Kisumu Density of Building rules appear to be very old but were still in force in 1972. These fules were clearly made by the Minister presumably under

Section 126 above subsection (e).

This particular section (e) is, important in relation to 'infrastructure' and also siting but it does not appear that general rules or others applying to specific Municipalities have been made.

It would also appear that the Building Rules are no longer in force since they are not attached to the revised Public Health Act of 1972. This is borne out by the fact that the Public Health (Drainage & Latrine) Rules which originated in 1948 and amended in 1959 and 1960 are attached.

Section 126A

This section has already been referred to in the paragraphs under General. It is this section which empowered the Minister of Local Government to introduce the Building Codes.

We should need to know not only how many councils have adopted the Building Code but also whether councils have in fact (as they are empowered to do) made amy By-laws of their own. It would appear that until either the Building Code is adopted or By-laws are made that there are no legal provisions applying to Building (as the old Building Rules did) except those provisions contained in the Public Health Act itself.

Section 126B

Allows L.A. to release its own By-laws with the approval of the Minister for Local Government and the Minister of Health.

There are conditions.

Section 126C

This deals with the procedure to be adopted for presentation of plans to the L.A.

It should be noted that there is provision in Subsection (3) for the determination by the Court (not any Minister) if an applicant considers the L.A. has not applied the By-laws correctly. There are conditions.

The prescribed period for the passing or rejection of plans is one month. The plans must be presented (when meetings are monthly) 3 days before and the period can be extended to 5 weeks.

The L.A. within the first month may extend the period by one further month.

The maximum period therefore becomes 66 days.

Section 126D

This is a long section dealing with work either commenced or undertaken illegally or where plans have been passed, building is not in accordance with the plans. It deals with the procedure and the Courts function.

PART X Protection of Foodstuffs

Section 127

Unspecific protection from rats. Subject on three occassions to the opinion of the Medical Officer of Health.

Appeal to the Court allowed who may acquit an accused if it is satisfied. That reasonable steps have been taken!

Section 128

Prevents the case of a kitchen or room used for food storage for residence or sleeping.

Gives powers to Medical Officer of Health.

PART XI Public Water Supplies, Meat, Milk and other articles of Food

*Section 129

L.A. to ensure that any water which the public has a right to use is not polluted dangerously to health.

L.A. has the duty to purify any polluted source.
Note: Polluted is not defined in the Act.

*Section 130

Empowers the Minister of Health may make rules applicable to defined areas for:-

Prohibiting bating in, clothes wahsing etc,

animal

which might cause water to be used for drinking etc. to be polluted.

Prohibiting or regulating the erection of:-

Dwellings

Sanitary convenience

Stables etc.

Dipping tanks

Factories

any of which might cause pollution.

Due regard to be paid to agriculture and other industries.

Note: Although the Drainage & Latrine rules do make some reference to pollution and effluents they were not made under Section 130 but under Section 126. No rules have been made up to 1972 under this Section.

PART XII The Prevention and Destruction of Mosquitoes

*Section 136

Spells out not only that mosquito breeding is a statutory nuisance (to be added to those in Section 118) but refers to other parasites of man or domestic animals. In practice this is a comprehensive section.

*Section 138

Premises or land shall not harbour mosquitoes. Overgrown bushes, long grass. Opinion of the MOH sufficient.

*Section 139

Wells etc. to be covered to provent entry of mosquitoes. To be properly protected or screened to the satisfaction of the MOH.

*Section 141

MOH may require gutters etc. to be perforated every 2 feet to prevent accumulations of water.

Immature stages of mosquitoes may be destroyed by application of oil or larvicide or otherwise.

Section 143

Presence of mosquito larvae an offence.

PART XIV

*Section 152

Should be read in full. Minister of Health may make rules for conduct and inspection of lodging houses.
Note: He has not done so up to 1972.

No person to keep lodging house unless the house is registered and the keeper is licensed by the L.A.

N.B.
Lodging House is defined in Section 2. It is clear that any house which sublets comes under this definition. According to

the lasw as it stands all such letting is subject to Section 152. Is this Section implemented in practice.

*Section 157(2)

Empowers the Minister of Health to make rules for:-

Preventing standing water

Drainage and control of standing water

Inspection repair and cleansing channels etc.

This in connection with the irrigation of land.

PART XV Miscellaneous Provisions

Sections 159-169

None of these sections are directly relevant to housing. They deal with procedural matters, powers, duties and prosecutions.

The final section 169 gives the Minister of Health powers to make rules generally. The Public (Medical officers of Health and Health Inspectors) Rules 1963 were made under this section.

Notes on Subsidiary Legislation to the Public Health Act relevant to housing

The Public Health (Drainage & Latrine) Rules.

This note will deal with the general provisions and application of the Rules. There compatability with other legislation will be discussed separately.

Rule 2

The Minister (of Health) may by notice apply the Rules to any area of a local authority.

All the Rules have been applied to:-

Kisumu Eldoret Nakuru Kitale	Municipalities
Nyeri Nanyuki Malindi Voi Thomsons Falls Kabarnet Karatina	Townships

Parts of Kiambu

Naivasha Urban District Council

Gilgil Township

Ol Kalon Township

Embu Township

County Council of Nairobi

The rules have also been applied to the following with the exception Rules 77-82 which relates to Licensing of Plumbers and Drainlayers.

Townships

Kakamega

Kisii

Kericho

Bungoma

Ngong

Kiambu

Limuru

All within Nakuru County & Lanet Planning Area

Kisii Township is not subject to Rules 18 and 24 dealing with inspection chambers in manufacturing premises and connections to public sewer by residents outside township area.

Note:

The Rules do not apply to Nairobi City Council or Mombasa Municipality. There is a reference to the City of Nairobi (Building) (Amendment) By-Laws 1965 in the published revised legislation. However, it is clear that By-laws made under 126A are not published as appendices to the law.

With regard to the Low-Cost Housing By-Law Study, it is important to discover what laws actually do apply. Of the 11 (eleven) towns selected, only 4 apparently apply the Drainage & Latrine Rules. Whilst it can be expected that Nairobi and

Mombasa have adopted or introduced suitable by-laws it seems unlikely that the others have done so.

General Note

Drainage and Sanitation or Latrine provisions are contained in at least the following:-

The Public Health Act. Part IX

The Public Health (Drainage & Latrine) Rules

The Local Government Act. Sections 168-176

*The Local Government Regulations 1963

The Local Government (Adoptive By-Laws) (Building) Order 1968

The Local Government (Adoptive By-Laws) (Grade II Building) Order 1968

It is probable that to these should be added:-

The City of Nairobi (Building) (Amendment) By-Laws 1965

By-Laws applicable to Mombasa

It would seem likely that Low-Cost Housing could be established by any Local Authority. At present and at this stage of the study, it is uncertain what legislation would apply to any particular area. The Grade II Adoptive By-Laws can at present be adopted by any municipal or country council. However, it appears that there are other Local Authorities. The Local Government Act defines a local authority as "a municipal council, county council, town council, urban or area council". It also in the definition refers to a local council which is defined as one established under section 48 of the Act. Part III of the Act sets out the law relating to Municipal Councils (5.12 ff) County and Town Councils (5.28 & ff) Urban and Area Councils (5.41 & ff) and Local Councils (5.48 & ff).

It would appear that in each case the law requires such Councils to be established. This may or not have been achieved, it may be that Kenya is administrately divided into Municipal and County Councils only but this seems unlikely.

On the other hand, the Local Government (Adoptive By-Laws) (Building) Order 1968, similarly can be applied only by any municipal or country council. Both the Adoptive By-Laws exclude from application areas to which one set of By-laws have been applied. In each case the By-laws need to be specific about application. In the Local Government (Adoptive By-Laws) (Building) Order 1968, By-Law 3 (3) contains the provision and in the Grade II By-Laws, By-Law 3 deals with application.

The situation is at present confused since it is possible that several statutory instruments could apply to the same area. In practice this is probably not important but at least any new By-laws or other instrument should be clear on what laws, rules, regulations or By-laws do actually apply.

There is nothing contained in the Grade II By-laws which relates to the requirements for general drainage, sanitation, roads, solid waste disposal of a housing area (infrastructure). The By-laws are concerned with individual plots and buildings or dwellings built upon them by plot owners. It seems clear that where these By-laws are silent on any particular matter or have not been adopted, the higher rules or laws will apply. In considering what laws apply to the 'infrastructure' it is probable that from the engineering point of view all relevant legislation must be taken into account.

The Public Health (Kisumu Density of Dwellings) Rules 1948

These Rules are made under Section 126 of the Public Health Act. They apply only to the Municipality of Kisumu. No similar rules had been made up to 1972.

They are possibly derived from some older provision since Rule 5 refers to the 1st April, 1929 though this could well be a misprint for 1949.

The rules include the following provisions:-

The proportion of plots to be built on
Limits development to 35 houses to an acre
Access to plots
Minimum frontage of 14 feet

The Public Health (Medical Officers of Health and Health Inspectors) Rules 1963

Made under Section 169 of the Public Health Act with reference to Section 9 (1A). In effect only Municipal Councils may with approval appoint a medical officer of health. Presumably, other MOH are direct appointees and employees of the Central Government. The position of Health Inspectors is not clear.

Rules 10 & 11

These contain the functions of the MOH and the HI respectively. It is clear that where they are appointed they have responsibility for all public health matters including health aspects of housing.

REFERENCES

(Not yet typed)